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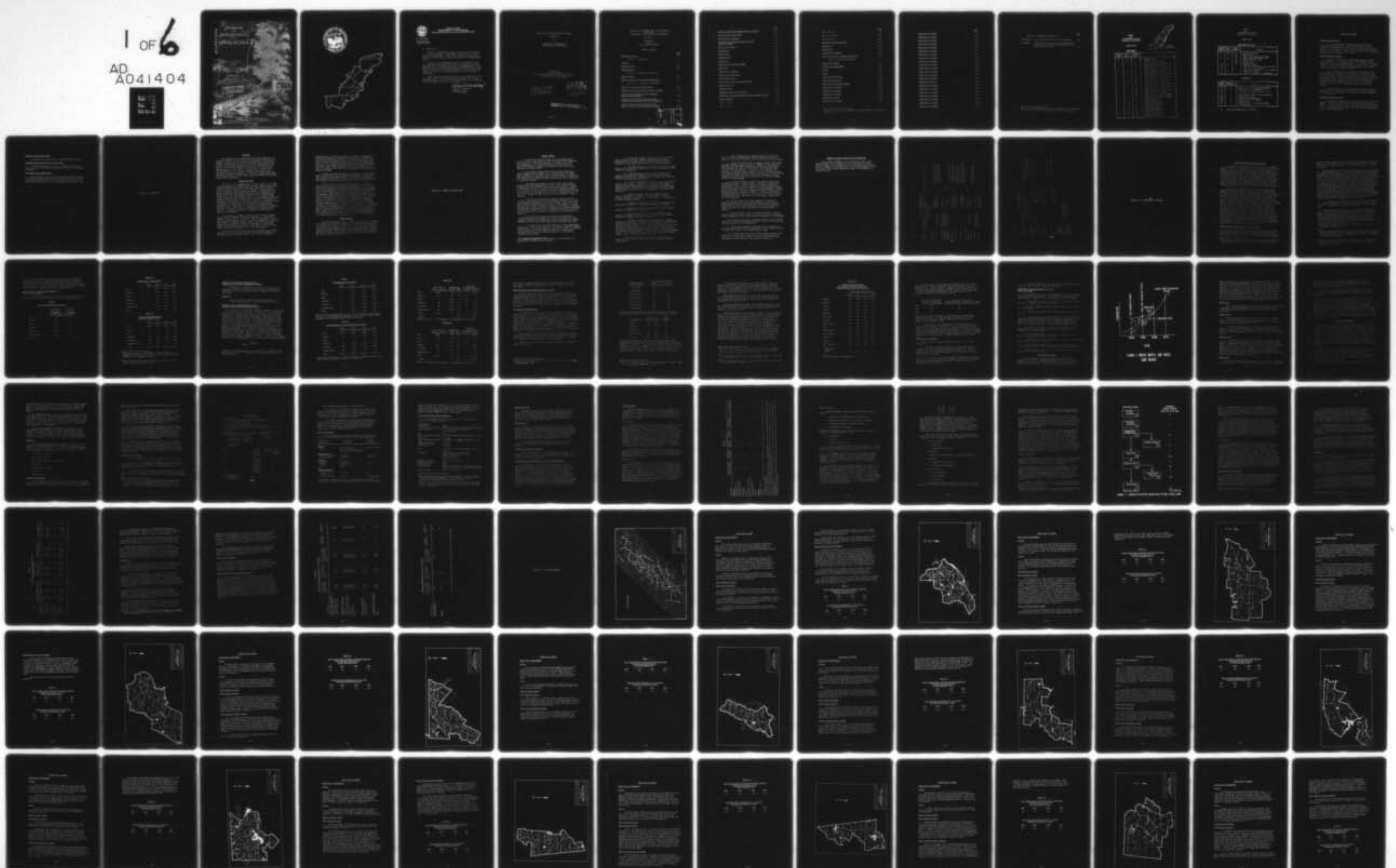

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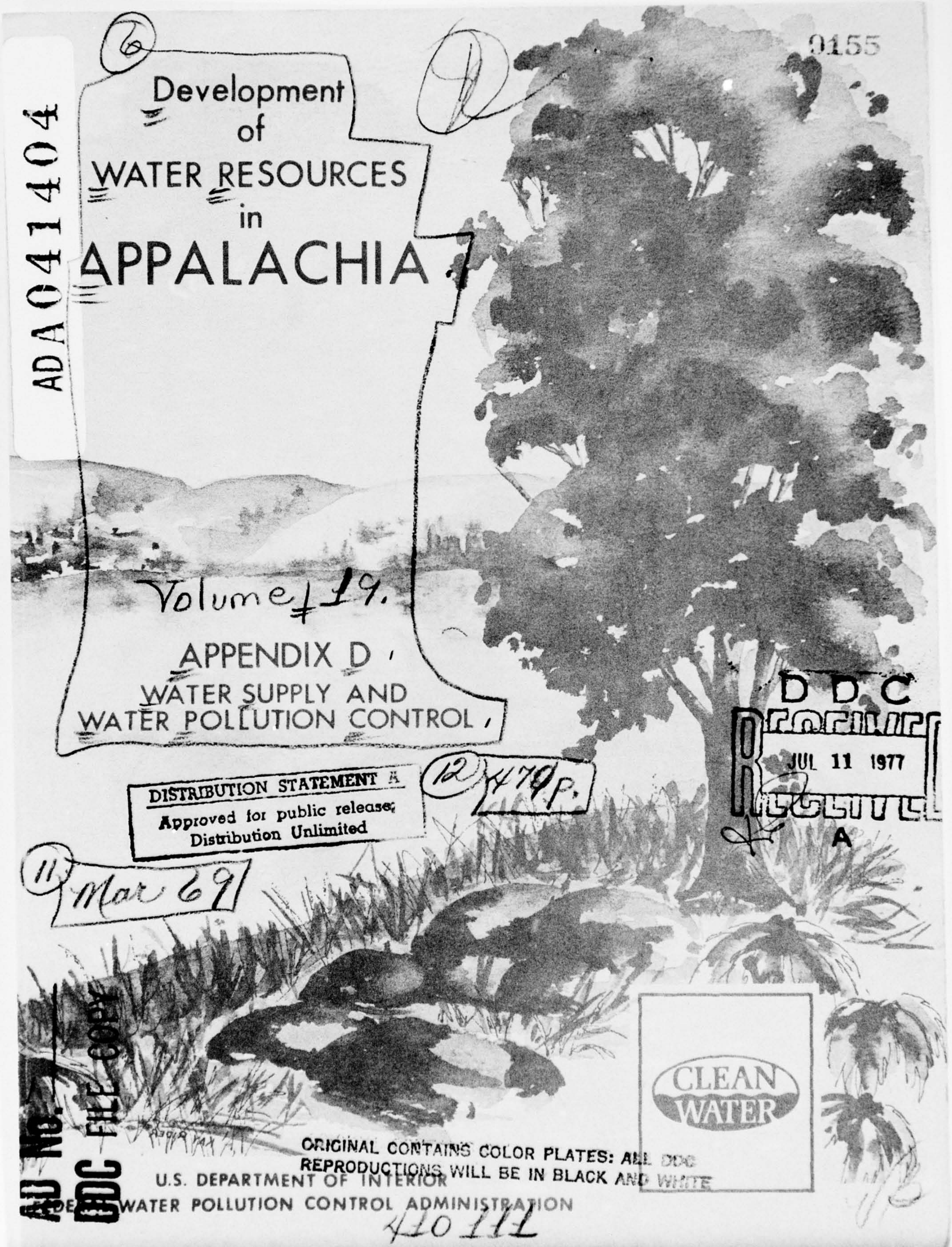
Development of WATER RESOURCES in APPALACHIA

Volume 19.

APPENDIX D

WATER SUPPLY AND WATER POLLUTION CONTROL



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U.S. DEPARTMENT OF INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

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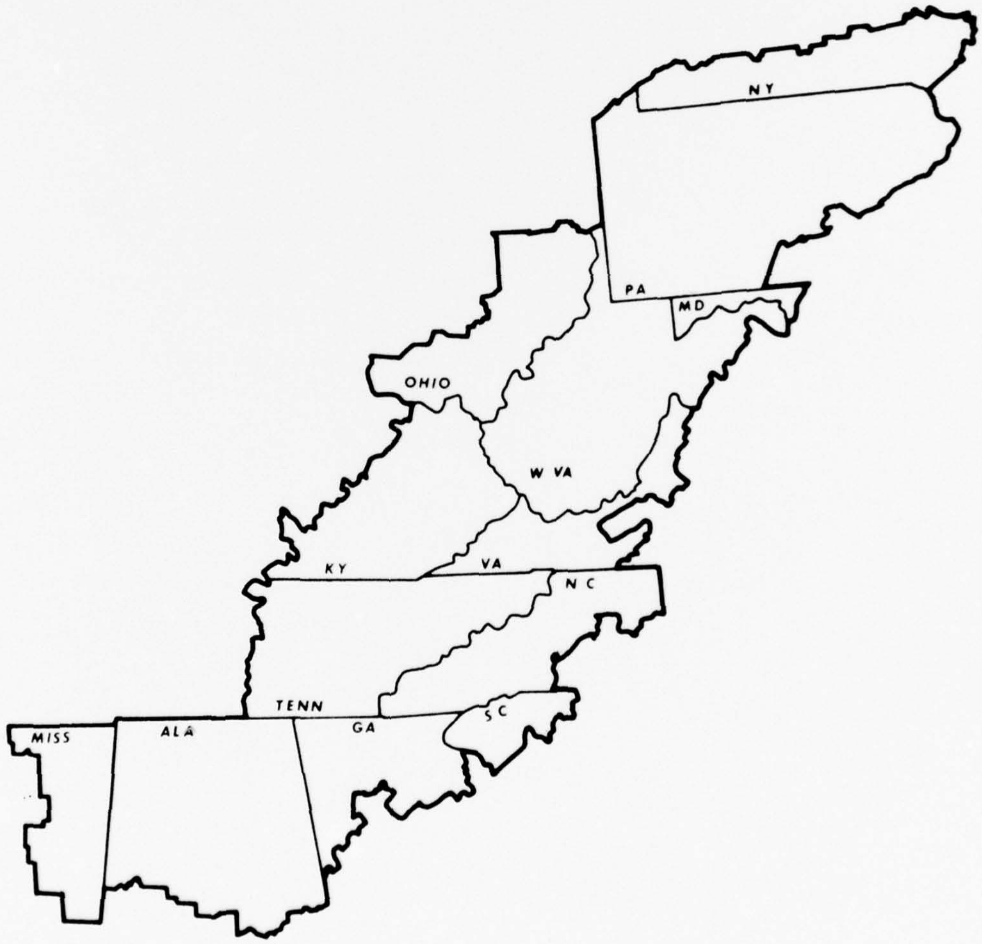

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

IN REPLYING ADDRESS:

OHIO BASIN REGION
4676 COLUMBIA PARKWAY
CINCINNATI, OHIO 45226

TO: THE READER

This document

Appendix D entitled "Water Supply and Water Pollution Control" is one of nine appendices to the "Report for Development of Water Resources in Appalachia." It furnishes information on water supply and water pollution control needs in and adjacent to the Appalachian region.

Included in this ~~appendix~~ document are a general appraisal of present and future water supply and water pollution control needs, and the ways and means of satisfying these needs. The ~~appendix~~ document also includes detailed discussions of water supply and water quality control needs that can be satisfied from selected reservoir projects that are proposed for inclusion in the Appalachian Plan for Water Resources Development.

Water resource developments for all uses are summarized in the main report which should be consulted for an overall view of the Appalachian region. An index for the report components and appendices is shown on pages vi and vii of this appendix.

Richard A. Vanderhoof

Richard A. Vanderhoof
Regional Director
Ohio Basin Region

WATER SUPPLY AND WATER POLLUTION CONTROL

APPENDIX D

to

REPORT FOR DEVELOPMENT OF
WATER RESOURCES IN APPALACHIA

Prepared by
Ohio Basin Region
Federal Water Pollution Control Administration
U.S. Department of the Interior

March 1969

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
REPORT FOR
DEVELOPMENT OF WATER RESOURCES IN APPALACHIA

APPENDIX D

WATER SUPPLY
AND
WATER POLLUTION CONTROL

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*Each water area resume is presented in identical format with identical subtitles.

*For detailed information contained in Supplements A and B (including specific project reports) see the Table of Contents, page D-105.

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For
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RESOURCES IN APPALACHIA

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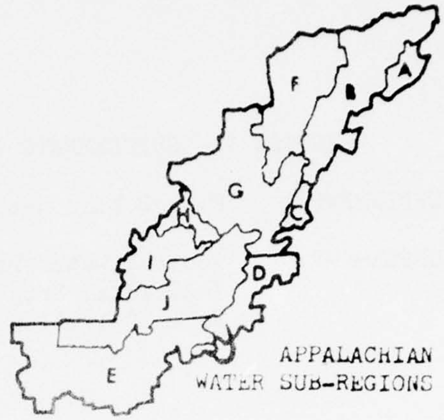

MAIN REPORT

Volume Number	Part Number	Chapter Number	Contents
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2	I	-	Key Map Folio (By States)
3	II	1	Water Sub-Region A Today
		2	Shaping the Plan for Sub-Region A
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APPENDICES

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16	A	Agriculture, Forestry and Conservation
17	B	Power Supply and Requirements
18	C	The Incidence and Formation of Mine Drainage Pollution
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Definition of Terms

Primary Sewage Treatment

This type of treatment commonly consists of screening, shredding and sedimentation. The process will remove a high percentage of suspended matter but little colloidal and dissolved matter. It is designed to settle the bulk of organic and inorganic solids that are insoluble. About 30 to 40 percent of the biochemical oxygen demanding materials can be removed.

Secondary Sewage Treatment

This type of treatment as conventionally applied involves the application of a biological process to the primary effluent in which bacterial or biochemical action is intensified to stabilize, oxidize and nitrify the unstable organic matter present. Activated sludge, trickling filtration, contact stabilization and extended aeration are common in secondary treatment.

In the secondary process, suspended and dissolved organic materials that can be attacked by organisms are partially or completely destroyed. Usually 80 to 95 percent of the oxygen demand, as measured by the biochemical oxygen demand test, will be satisfied. Although under proper conditions and with sufficient time, all biodegradable organic materials may be degraded by appropriate organisms; complete degradation does not occur on a practical basis and some residual or refractory materials remain in the effluent.

Methods other than those conventionally used which might be presently used or developed for future use, and which would produce an equivalent of effluent would be considered secondary treatment in this appendix.

Population Equivalent (P.E.)

The measure of strength of a waste converted to the equivalent number of people required to produce the same biochemical oxygen demand. In terms of ultimate first stage biochemical oxygen demand (BOD), 0.25 pounds of BOD is considered as one population equivalent. (This is also approximately equal to 0.17 pounds of BOD as measured by the standard 5-day test.)

Million Gallons Per Day (mgd)

An abbreviation used to signify a million gallons per day.

Standard Metropolitan Statistical Area (SMSA)

An abbreviation used to designate a "Standard Metropolitan Statistical Area" as defined by the Bureau of Census, U.S. Department of Commerce.

Biochemical Oxygen Demand (BOD)

An abbreviation used to designate "biochemical oxygen demand" as measured by methods described in "Standard Methods for the Examination of Water and Wastewater" by the Publication Office, American Public Health Association, Inc., 1790 Broadway, New York, N.Y. 10019.

SECTION I - INTRODUCTION

AUTHORITY

The authority for the water resources study for Appalachia is contained in Public Law 89-4, titled the "Appalachia Regional Development Act of 1965." The Act authorized the Secretary of the Army to prepare a comprehensive plan for the development and efficient utilization of the water and related resources of the Appalachian Region. Section 206.(c) of the law further stipulated, "To insure that the plan prepared by the Secretary of the Army shall constitute a harmonious component of the regional program, he shall consult with the Commission and the following: the Secretary of Agriculture, the Secretary of Commerce, the Secretary of Health, Education, and Welfare, the Secretary of the Interior, the Tennessee Valley Authority, and the Federal Power Commission."

PURPOSE AND SCOPE

The purpose of Sections I through IV of this appendix is to give a general appraisal of the water supply and water quality control needs of the Appalachian area. Twenty-eight water areas were selected for reporting purposes consistent with the geographic breakdown used for report purposes by various cooperating agencies. Benchmark goals of economic development were defined, which for planning purposes, estimated the population and economic development that reasonably might be attained. These "developmental goals," in turn, established the economic framework used to estimate the need for municipal and industrial water and the water quality control needs that would be expected to accompany the attainment of these goals. Comparison of these needs with the present and planned water resource development permitted the determination of the adequacy of development to meet such needs on a water-area basis. These goals are considered applicable on an areawide basis and not subject to reliable disaggregation to smaller areas; therefore, community-by-community or county-by-county needs were generally not attempted.

The location of the major development within a water area may greatly affect the program that might be necessary for water supply and water quality control. The general impact of development in one part of the water area as opposed to another was attempted in the water area resumes. In addition, greater detail is provided for specific project reports (included in Section V, Supplement B) where a more detailed economic study was conducted. This detail is limited to the project report and not repeated in the water area resumes.

The population and economic development indicated by the benchmark goals will, in some areas, require a considerable investment to meet water supply and/or water quality control needs. Generally,

alternates exist to satisfy the needs. The range of alternates and complementary measures for water pollution control is discussed in Section III under "Control Methods." The alternate selected in any given situation will depend on many variables, including land availability, types of wastes, stream hydrology, stream uses, and geologic conditions. The program that might result is not capable of exact definition within a water area; however, certain factors which will lead to preference of one alternate over another are considered in the water area resumes.

Section V includes Supplement A, provided by the Public Health Service, Department of Health, Education, and Welfare. This supplement consists of environmental health guidelines which delineate basic measures which should be included in water resource and related land planning to protect the environmental health of the area.

Section V also includes Supplement B, which is a series of reports on specific projects studied in greater detail for possible authorization as part of the Appalachia Water Resources Study. These reports were prepared by the FWPCA regional office having responsibility for the Federal water pollution control program in the specific project area. These reports include more detailed and specific recommendations than that included in the water area resumes and are based on more intensive economic and water quality studies. Excluded from the presentation in both the water area resumes and project reports is a significant consideration of water quality standards that will apply to the interstate streams, and by State initiative, to many intrastate streams (see Section III "Water Pollution Control Program" for an elaboration on water quality standards). The concurrent time frame for the preparation of this appendix with the establishment of interstate stream standards by the Secretary of the Interior makes a substantive evaluation of the impact of standards impossible within report deadline commitments. For a further elaboration into the significance of these project reports, the reader is referred to the Introduction section of Supplement B.

ACKNOWLEDGMENTS

The various regional offices of FWPCA, in preparation of material for project reports and water area resumes, have obtained information from a variety of sources. In addition to the various Federal agencies cooperating in this study, the Department of Health, Economic Development, and Natural Resources of the 13 Appalachia States have provided background material. The coordinating committee of State officials and participating government agencies have provided continuing cooperation and helpful direction in this study.

SECTION II - SUMMARY AND CONCLUSIONS

GENERAL SUMMARY

1. Municipal and industrial water uses in Appalachia (exclusive of uses in agricultural, mining, and thermal power operations) are estimated at 7,700 million gallons per day (mgd), and to meet the benchmark goals of economic development, these uses will be expected to require approximately 13,300 mgd by 1980, 23,400 mgd by 2000, and 42,200 mgd by 2020.

2. Raw untreated organic waste loadings from industry and sewered communities are estimated to be the equivalent of the wastes from a population of 34,300,000, and if benchmark goals of economic development are met, these wastes are expected to increase to 60,000,000 P.E. (population equivalent) by 1980, to 105,500,000 P.E. by 2000, and to 176,000,000 by 2020.

3. The greatest percentage increase in water use and waste loadings under study assumptions will occur in the southern portions of Appalachia, with Subregion J showing an increase from 14.4 percent of total water use and 12.2 percent of raw waste loadings at present to 34.3 percent of water use and 22.2 percent of waste loadings by 2020. For Subregion E the increases from 1960 to 2020, respectively, are from 8.0 to 11.5 percent for water use and 8.6 to 13.5 percent for waste loadings.

4. To provide secondary waste treatment facilities for all presently sewered areas not now having secondary treatment will require an investment of approximately 275 million dollars over the next five years, assuming a design population equal to 1990 estimates. Excluded are the costs of sewers including interceptors, separation of storm and sanitary sewers, and pump stations. Average annual investment thereafter for secondary treatment facilities are expected to be about 25 million dollars. These values are based on construction costs applicable in early 1967.

5. With secondary treatment of municipal and industrial bioxidizable wastes and an equally high level of treatment for other industrial wastes, the following major problems are expected to require attention to control water quality and protect legitimate water uses:

a. Protection of the areas' waters will require increasing attention to control of nutrients which contribute to undesirable aquatic plant growths. It has been determined that nutrient control is essential for the restoration of water quality in Lake Erie. Particularly vulnerable are the series of impounded waters in the Ohio and the Tennessee River systems.

For conclusions applicable to certain specific stream reaches, see Supplement B for specific project reports.

b. Storage for streamflow regulation should be provided where justified to increase streamflow and waste assimilation during periods of low flow; however, emphasis should be placed on improved treatment rather than relying on flow regulation alone.

c. Off-stream cooling methods should be provided in areas where heat pollution or heat aggravated pollution problems are or are likely to be significant.

d. A program of correcting acid mine drainage at the source in both active and "abandoned" mines should be promoted. Legislation providing for controlling mine discharges and reclamation of strip mine areas should be advanced.

e. Pollution from sediment should be brought under greater control. Major sources of sediment pollution include: exposed banks from strip mining, coal fines from improperly controlled coal washeries, piles of debris from mining operations, improper forestry and other agricultural practices, and highway and other construction operations.

f. State, interstate, and Federal agencies should with the cooperation of industry, initiate programs to prevent or minimize the effect of pollutional incidents caused by spillages of oil and other hazardous materials.

g. Prevention of discharges of toxic concentrations even where long-term effects on health are unknown must be achieved.

h. Appropriate controls for discharges of taste and odor producing substances should be provided.

i. Specific methods of brine waste disposal from oil fields and industrial processes should be recommended and programs developed to implement the recommendations.

j. Proposed new sewerage facilities should be designed to prevent the necessity of bypassing untreated wastes. Combined storm and sanitary sewers should be prohibited in all areas that are to be developed, and eliminated in existing areas where the resulting improvement would justify expenditures. Existing combined sewer systems should be patrolled and flow-regulating structures adjusted to convey the maximum practicable amount of combined flows to and through treatment plants. This is particularly necessary in areas where current waste loads are producing serious stream degradation.

6. State or interstate planning and implementing agencies should be established to conduct water quality programs for entire river basins.

7. Detailed investigations should be made of the practicability and costs of advanced waste treatment methods, diversion of wastes, or other means of water pollution control in all problem areas.

8. To meet the needs by 1972 to design, construct, and operate new waste treatment plants and improve operation in older plants, an estimated 6,600 additional professionals, technicians and treatment plant operators will need to be employed for the Appalachian area. Of these, 1,850 are expected to be needed as plant operators for municipal and industrial waste treatment plants. Training courses at vocational educational schools should be considered at several locations in Appalachia to meet this need. The States, Department of Health, Education, and Welfare, and FWPCA should mutually cooperate in plans to meet this training need.

9. Providing storage in reservoirs can have both beneficial and degrading effects on water quality. Some possible effects are thermal stratification, reduced turbidity, increased plankton and algal growths, reduced coliform organisms, decreased dissolved oxygen in stratified water, possible increase in iron and manganese in bottom waters, and general smoothing or equalizing effects on mineral quality. Reservoirs should be operated in a manner to decrease or eliminate the degrading effects. Multiple-outlet structures in projects should be considered wherever appropriate to provide water of good quality for flow regulation.

10. Stream quality surveillance programs for purposes of measuring compliance with water quality standards, as well as for other purposes, should be integrated such that suitable information obtained by the various State, interstate, and Federal agencies is freely available and so that duplication of efforts and costs is avoided.

11. A study should be made to determine the extent to which deep-well disposal of wastes may be technically feasible in Appalachia and to recommend criteria and procedures for regulation of such disposal.

12. Mining operations were the greatest single cause of reported fish killed in 1966 in Appalachia, amounting to about 45 percent of the 3,000,000 reported killed in Appalachia.

13. Food processing wastes contributed about 27 percent of the total reported fish killed in Appalachia in 1966, primarily because of the one very large kill in Alabama from this cause.

14. On a percentage basis, agricultural operations were a very minor cause of fish killed in Appalachia. Agricultural operations were also a relatively minor factor in Appalachia as compared with the nation, for both fish killed and number of incidents.

SUMMARY OF SPECIFIC PROJECT STUDY CONCLUSIONS

Table I shows a summary of the conclusions of water supply and water quality control needs that are incorporated in specific project studies. This summarization lacks the specificity and detail which is included in the project report and the reader should refer to the specific report before attempting to apply the information to a specific project.

Table I

Summary of Water Supply and Water Quality Control Needs
Special Project Reports

Project	Water Supply Need and Location	Water Quality Need and Location	For Detail See	Special Comment
	(The fact that a need might feasibly be met by a specific project does not mean that the project is the best alternative method of meeting a specific need.)			
Royal Glen Reservoir	No need	No need	p. D-133	
Hipes Reservoir		128,000 acre-feet Mainly the James River below Lynchburg and Richmond, Va.	p. D-181	Water quality benefits accrue largely outside Appalachia, incidental unquantified benefits will accrue in Appalachia area.
Clinchfield Reservoir	140 Mgd (21,300 acre-ft.) for upper portion of Broad Basin.	Pacolet River below Spartanburg, South Carolina.	p. D-155	Water quality need can be met alternately by advanced waste treatment, reservoir on North Pacolet River or piping of treated wastes to Broad River and providing storage in Clinchfield Reservoir.
Roaring River Reservoir	None if needs are met as planned from W. Kerr Scott Reservoir.	35,000 acre-feet for Winston-Salem area.	p. D-171	
Curry Creek Reservoir	Athens-Clarke County area and Jefferson, Georgia, 10.7 Mgd.	No need	p. D-211	
Dalton Reservoir	137 Mgd for Dalton, Georgia, area.	226 cfs for Dalton, Georgia.	p. D-217	
Coosa River Navigation	———	———	p. D-217	Further studies relating to Mayo's Bar should be conducted if project receives favorable consideration.
Stannard Reservoir	———	80 cfs below Wellsville, New York, net storage need of 5,100 acre-ft. below Wellsville, New York.	p. D-375	Water quality need at Wellsville is based on a planned location of a pulp and paper mill in the Wellsville area.
St. Petersburg Reservoir	No need	110,000 acre-feet of storage for the Ohio River near Pittsburgh.	p. D-281	Water quality storage in the project is an alternate for other sources, use of project storage for release and obtaining recreation benefits in the reservoir require a mine drainage abatement program.
Greenbrier Reservoir	No need	12,500 cfs below Charleston, West Virginia, on the Kanawha River part of which could be provided by the Greenbrier Reservoir.		Information on this project was not specifically requested for the Appalachia study separate from that provided for the Kanawha Type II Study. Type II Study information was provided for project formulation purposes.
Lower Knox Creek Reservoir	No need	40 cfs for Tug Fork of the Big Sandy.	p. D-336	
Whiteoak Reservoir	7.9 Mgd for the Whiteoak Basin	7 cfs below Georgetown, Ohio, on Whiteoak Creek.	p. D-279	
Logan Reservoir	———	———		Information in addition to that supplied in "House Document No. 287, 89th Congress" was not officially requested for the Appalachia Water Resources Study.
Upper French Broad	24,500 acre-feet Asheville-Henderson area, and for industry in Upper French Broad area.	32,000 acre-feet for area below mouth of Davidson River.	p. D-219	
Yellow Creek Port	No need	Discharge of treated effluents to the Tennessee River and/or advanced waste treatment.	p. D-229	

Table 1 (Cont.)

Summary of Water Supply and Water Quality Control Needs
Special Project Reports

Project	Water Supply Need and Location	Water Quality Need and Location	For Detail See	Special Comment
Department of Agriculture, Upstream Reservoirs	(These reports are preliminary in nature and would require more detailed study and comment at such time as individual projects are further developed.)			Preliminary comments for potential projects were transmitted to the Department of Agriculture for a detailed identification of potential water supply and water quality control needs which might be met. See Appendix A.
The following reports were formulated for projects which were investigated but not carried to project formulation or are background for conclusions in Part II relating to future developmental needs.				
Prompton Reservoir	No need	Salinity control in Delaware Estuary.	p. D-119	A portion of salinity control need might be assigned to this reservoir.
Davenport Center Reservoir	Binghampton, New York, 19,000 acre-feet.	Susquehanna River below Binghampton, New York, 33,800 acre-feet.	p. D-121	
Celina Reservoir	No need	No presently indicated need. Further studies below Nashville, Tennessee, are needed.	p. D-339	
Devils Jumps Reservoir	No need	No need for reservoir storage. Mine drainage abatement is needed.	p. D-355	
Parker Branch Reservoir	No need	No need	p. D-369	
Kingdom Come Reservoir	No need	3,400 acre-feet net storage from Carr Fork and Kingdom Come Reservoirs.	p. D-371	Recreational benefits may be adversely affected by mine drainage from sources above the project.
Conneaut Creek Protection	————	————	p. D-373	No combined sewers should be incorporated in project which will discharge untreated wastes.
Zoar Reservoir	————	Advanced waste treatment with nutrient (phosphorus) removal is recommended at Gowanda in accordance with the Lake Erie enforcement conference.	p. D-379	
Area F Framework Study-- Conemaugh Basin	These reports are preliminary in nature and include many projected water supply and quality control needs which would require further study if specific projects in these areas are carried to advanced study stages.		p. D-233	
Area F Framework Study-- Tygart Valley Basin			p. D-243	
Area F Framework Study-- West Fork Basin			p. D-251	
Area F Framework Study-- Youghiogheny Basin			p. D-259	
Area F Framework Study-- Conewango Creek, Cassadaga Creek, Brokenstraw Creek, Raccoon Creek, Big Sandy Creek, Dunkard Creek			p. D-269	

SECTION III - PROCEDURES AND RATIONALE

WATER SUPPLY NEEDS AND WASTE LOADINGS

The demand for water and the waste loads which are produced depends largely on the population and the type and amount of economic activity in an area. Economic studies are therefore essential to relate current requirements and to estimate future requirements for both water supply and water pollution control. The economic studies for this survey involve the concept of planning public investments to implement regional objectives. Evaluation procedures to meet such objectives were developed by the Department of the Army, Office of Appalachian Studies.[1/] Based on this concept, tested "benchmark goals" of development were formulated for the various water areas under the leadership of the Office of Appalachian Studies. For a detailed discussion of economic methods and rationale, see Appendix E.

The estimate of water supply needs is based on an initial assumption that availability will not be a limiting factor within a water area, and that price will not limit use in the future any-more than it has in the past. The estimate obtained is then compared with the existing and readily developable supplies in an area. In the water area resumes judgmental factors are then considered in describing those portions of a water area having greater or lesser amounts of naturally available or developable resources to meet these needs. This accomplishes an initial step of alerting planners to areas where more detailed studies may be necessary to meet needs. The project reports are examples of these more detailed studies (see Section V). Inherent in the evaluation of water availability is the assumption that water pollution will be controlled such that available supplies will be usable. Generally, major water-using industries are expected to factor in cost of water supply in their location decisions and, therefore, long transmission lines to obtain major quantities of water will be avoided in most cases. Appalachia is an area of high precipitation and runoff and, therefore, with proper management of water resources, should not be at a disadvantage in comparison with other parts of the country in having an economical supply of water for municipal and industrial uses.

INDUSTRIAL WATER SUPPLY NEEDS AND WASTE LOADINGS

Estimates of industrial water requirements and waste loadings generated by economic development are complicated by many factors. Every product requiring water in its manufacture utilizes differing quantities and qualities of water and even the manufacture of identical

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[1/] "Evaluation Procedures for Water Resource Planning," U.S. Department of the Army, Corps of Engineers, Office of Appalachian Studies, Cincinnati, Ohio.

products differ in amounts of water used and waste loadings generated, depending on processes involved and in-plant practices used. The prime uses of water in industry are for cooling or condensing and for product processing.

Industrial water use has been computed on a daily use per employee or per unit production basis. The Bureau of Census[1/] has collected water use figures for various regions in the United States for the four-digit industrial categories. The Business and Defense Services Administration (BDSA) of the U.S. Department of Commerce prepared a statistical analysis of this information for the Appalachian area.[2/] This information was both useful and used, and the industrial water use figures indicated in the BDSA report are consistent with those presented in this appendix. The figures presented in the Census report were statistically analyzed in a recent study[3/] and the conclusion reached that either employment or value added by manufacture could be used in estimating industrial water use in most cases. In a few cases no significant correlation could be demonstrated to exist. Similarly, Eichberger[3/] presented data on waste loadings by Standard Industrial Classification (SIC) categories. Present water use and waste loading values were obtained where possible and used for the evaluation by water areas. Where information was lacking the statistically determined values were used.

The determination of industrial water supply and waste loadings are illustrated by showing the step-by-step procedures used for water area I-1. The same basic procedures were used for the other 27 water areas.

Water supply and waste load vectors were assigned for the six major two-digit SIC water using industrial categories. The values shown for water area I-1 were modified for certain other areas. This modification was based on knowledge of the present development and judgments of most likely future development for the specific area. The adjustment in vectors assigned for a two-digit SIC grouping for a specific water area allows for factoring in knowledge on the most

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[1/] U.S. Bureau of Census. 1963 Census of Manufactures: Water Use in Manufacturing, MC63(1)-10.

[2/] "Water Use by Appalachian Manufacturers," prepared for the Office of Appalachian Studies, Corps of Engineers, U.S. Department of the Army, by the Business and Defense Services Administration, U.S. Department of Commerce, December 1967.

[3/] "Industrial Water Use," by Willis G. Eichberger, U.S. Department of Health, Education, and Welfare, Public Health Service. (For administrative use only.)

likely type of development for the specific area under consideration. For example, within the SIC 20 (food and kindred products) category, slaughterhouses, dairies, bakeries, and canneries utilize considerably different quantities of water per employee and magnitudes of waste loading per employee. Obviously the exact mix that might evolve would greatly affect the amount of water used and waste loadings generated.

Basic Data for Industrial Water Supply and Waste Loading Estimates

Three tables are basic for the evaluation of water supply needs and waste loadings. These tables for water area I-1 are shown below:

Table II

Water Supply and Waste Load Vectors

	Present Water Supply Vector (Gals/Emp/Day)	Present Waste Load Vector (P.E./Emp/Day)
Food	700	14
Textiles	600	2
Paper	8,850	126
Chemicals	9,100	10
Petroleum	13,300	2
Primary metals	14,500	2
Other	150	2

Table III

Productivity for Water Area[1]

	1960	1980	2000	2020
Food	1	1.26	1.66	2.17
Textiles	1	2.85	5.02	7.86
Paper	1	1.25	1.51	1.84
Chemicals	1	2.42	3.93	6.32
Petroleum	1	1.96	3.23	4.87
Primary metals	1	1.32	1.67	2.03
Other	1	1.52	2.33	3.60

Table IV

Tested Benchmark Employment
Table for Water Area I-1[2]

	1960	1980	2000	2020
Food	1,494	3,166	5,146	4,744
Textiles	64	75	62	67
Paper	0	0	0	0
Chemicals	257	757	1,757	2,168
Petroleum	387	544	753	1,084
Primary metals	108	80	57	51
Other	8,194.	22,271.	36,154	54,372

1/ From data presented in "Economic Base Study Information" for Appalachia area by Regional Economics Division, Office of Business Economics, U.S. Department of Commerce.

2/ From information presented by the Nashville District, U.S. Army Corps of Engineers, on March 8, 1967.

Industrial Water Supply and Waste Loading Estimates Unadjusted for Technological Advances

The product of the appropriate factors in the preceding tables produces an estimate of water use (or waste loading) by choosing the appropriate factors for the desired year and industrial category as shown below.

Equation A

Water use estimate = gallons/employee/day (Table II) x productivity (Table III) x tested employment (Table IV)

Industrial Water Supply and Waste Loading Estimates Adjusted for Technological Advances

The estimate in the preceding paragraph assumes no increased efficiency in terms of water use per unit of production. It is reasonable and consistent with past trends that as technology is applied to more effectively use our labor force and accomplish improved productivity, there will be a concurrent use of technology to reduce water use and waste loading per unit of product. No technological advances in water use per unit of product would result in water use paralleling production as shown in equation A above. Technological advances in control of water use and waste loadings equal, on a percentage basis, to those applied to increased employee productivity would result in water use paralleling employment. It is believed that the actual water use and waste loading trend line will be somewhere between the employment trend line and the total product trend line. The simplifying assumption of estimating the actual water use to be half-way between the employment and total product lines is considered consistent in degree of probable accuracy with other basic elements of the study. Applying this rationale, we can produce a "New Employment Factor Table" from the following equation:

$$\text{New } Xi_j = \frac{1.0 + Xi_j}{2}$$

in which Xi_j is the appropriate productivity value by industry (i) and year (j) from Table III. This table as derived from water area I-1 is shown as follows:

Table V

New Employment Factor Table

	1960	1980	2000	2020
Food	1	1.13	1.33	1.585
Textiles	1.	1.925	3.01	4.43
Paper	1	1.125	1.255	1.42
Chemicals	1	1.71	2.465	3.66
Petroleum	1	1.48	2.115	2.935
Primary metals	1	1.16	1.335	1.515
Other	1	1.26	1.665	2.30

From the product of appropriate values in the "New Employment Factor Table" and Table IV, "Tested Benchmark Employment Table, Table VI, called "Tested Employment x New Employment Factor Table," is obtained:

Table VI

Tested Employment x New Employment Factor Table

	1960	1980	2000	2020
Food	1,494	3,578	6,844	7,519
Textiles	64	145	189	300
Paper	0	0	0	0
Chemicals	257	1,295.	4,331	7,937
Petroleum	387	805.	1,592	3,182
Primary metals	108	92	77	78
Other	8,194.	28,062.	60,196	125,056

From the foregoing tables, the desired estimate of industrial water use and waste loading is obtained, as shown in the following:

Year 1960

	Tested Emp. x New Emp. Factor 1/	Water Use Gal/Emp.	Water Use mgd	Untreated Waste Load P.E./Emp.	Untreated Waste Load P.E./Day
Food	1,494	700	1.05	14	20,920
Textiles	64	600	0.04	2	128
Paper	0	8,850	0	126	0
Chemicals	257	9,100	2.34	10	2,573
Petroleum	387	13,300	5.15	2	775
Primary metals	108	14,500	1.58	2	217
Other	8,194	150	1.23	2	16,389
Totals			11.38		41,004

1/ This is from the tested employment x new employment factor table.

Year 1980

	Tested Emp. x New Emp. Factor 1/	Water Use Gal/Emp.	Water Use mgd	Untreated Waste Load P.E./Emp.	Untreated Waste Load P.E./Day
Food	3,578	700	2.50	14	50,097
Textiles	145	600	0.09	2	291
Paper	0	8,850	0.0	126	0
Chemicals	1,295	9,100	11.79	10	12,955
Petroleum	805	13,300	10.72	2	1,611
Primary metals	92	14,500	1.35	2	185
Other	28,062	150	4.21	2	56,124
Totals			30.66		121,266

1/ This is from the tested employment x new employment factor table.

The calculation procedures were applied to other target years and other water areas to make up a component of the tables included in the water area resumes.

MUNICIPAL WATER SUPPLY NEEDS AND WASTE LOADINGS

Municipal water supply needs and waste loadings as evaluated for this study include domestic, commercial, and public water use from central systems and waste discharges to central treatment plants; they do not include the industrial water use from central systems or industrial waste loadings to central systems even though many industries use these systems. The industrial component associated with these systems is evaluated along with the self-supplied water supply and waste discharge facilities provided by industry.

Municipal Water Supply Needs

The demand from municipal water supply systems is created by a number of special uses, i.e., domestic, commercial, public, fire fighting, and industrial. The size of the community, its location, number and diversity of commercial business establishments; community habits; availability; quality; and cost of water; existence of sewers; public policy with respect to civic duties, and size and type of industries within any city are characteristics peculiar only to the city under consideration. As a consequence, the municipal water demand computed on a per capita basis can be expected to vary among cities. Municipal use is largely nonconsumptive and it can be expected that about 90 percent of the water used for municipal purposes will be returned to the water courses.

For purposes of developing overall data on municipal water demand, writers have grouped cities by population brackets to determine water use. This method furnishes a general idea of the overall quantity of municipal water demand that is deemed sufficient for this appendix.

Porges[1/] broke down per capita consumption figures by population groups as follows:

[1/] "Factors Influencing per capita Water Consumption," Ralph Porges, Water and Sewage Works, May 1957.

Population Group	U.S. Average Demand (gpcd) 1948	1954
500-1,000	100	
1,000-5,000	108	
5,000-10,000	114	129
10,000-25,000	123	134
25,000-50,000	127	133
50,000-100,000	121	129
over 100,000	157	150

Porges further reported[1/] that for an average output of 149 gallons per capita daily (gpcd), the distribution of water was as follows:

Use	1954 gpcd	1954 percent	1958 percent
Domestic	64	42.8	41
Commercial	28	18.9	18
Industrial	37	24.9	24
Public & other	20	13.4	17
Totals	149	100.0	100

The above tabulation also shows a distribution of municipal water use made from an analysis of the 1958 Public Health Service Inventory of Public Water Supplies. This analysis included 580 communities serving about 84 million people. Communities with a population less than 100,000 averaged 132 gpcd, while communities with a population greater than 100,000 averaged 150 gpcd. These figures compare closely with the use rates found in Porges, earlier survey for these size categories.

1/ "Who Gets How Much of What Kind of Water--from Where and Whom?", Ralph Porges, Water Works Engineering, February 1957.

The State of Ohio Department of Natural Resources[1/] reported on results of an extensive study of municipal water supplies. Comparing the per capita use figures for the various population categories, the figures for Ohio are somewhat lower than the U.S. figures in the previous tabulation. The distribution by types of uses reported for Ohio closely approximated those given by Porges.

Medium-range projections[2/] for those States that have land areas in the study area are shown below. Included also in the tabulation are the 1960 water use figures for public supplies presented by MacKichan and Kammerer[3/] for these States.

These medium projection trends show a steady per capita water use for the various States in Appalachia; however, these are average figures and tend to be less than the gpcd figures for municipalities with a population greater than 100,000.

Future municipal water use values were obtained from the projections previously shown from the 1960 Select Committee report. An average per capita use of 133 gallons per day, half-way between the national value of 148 and Appalachia median value of 117, was selected for 1980. For the year 2000 a value of 143 gallons per capita per day was selected. This value assumes per capita use in Appalachia will increase over that shown in the Select Committee report to within one-fourth the differential between the national projection of 152 and Appalachia State median value of 116 gallons per capita per day for the year 2000. For the year 2020 a value of 154 gallons per capita per day for Appalachia was selected. This would bring Appalachia per capita municipal water use up to the national value if the Senate Select Committee projections were extended from 2000 to 2020. The increased per capita values were used on the assumption that a successful developmental program for Appalachia would result in increased per capita use accruing from an affluence in Appalachia more nearly approximating that of the nation.

1/ "Municipal Water Supply in Ohio, 1955 and 1957," Anthony R. Rudnick, Report No. 9 Ohio Water Plan Inventory, State of Ohio, Department of Natural Resources, Division of Water, July 1962.

2/ Water Resources Activities in the U.S. Future Requirements for Municipal Use, Select Committee Print No. 7, 86th Congress, 1960.

3/ Estimated Use of Water in the U.S., 1960 Geological Survey Circular 456, K.A. MacKichan and J.C. Kammerer, 1961.

Table VII

Municipal Water Use from
1960 Select Committee on National
Water Resources, United States Senate

	Gallons per capita per Day			
	1954	1980	2000	1960*
National	147	148	152	151
Alabama	105	100	98	118
Georgia	127	119	117	161
Kentucky	125	137	136	138
Maryland	131	117	116	127
Mississippi	107	110	113	113
New York	138	148	153	136
North Carolina	108	106	106	131
Ohio	149	147	147	138
Pennsylvania	147	154	154	144
South Carolina	108	98	96	137
Tennessee	119	112	112	142
Virginia	100	90	89	129
West Virginia	112	127	132	99
Median for Appalachia States	119	117	116	136

*See reference (3) on preceding page.

The above values for per capita use from municipal water supplies were adjusted to represent only that representing domestic, commercial, and public uses. For this purpose 25 percent of the use was assumed to be for nonself-supplied industry, consistent with the percentages shown in Porges' study previously tabulated. The resulting values used in the study for 1980, 2000, and 2020 are shown below:

	Per Capita Demand from Municipal Systems, gpd	Per Capita Demand from Systems Exclusive of Industrial Use, gpd
1980	133	100
2000	143	107
2020	154	115

The deletion of industrial water in calculating use from municipal systems is necessary, since the rationale for projecting industrial water use will include all industrial use whether self-supplied or supplied from a municipal source.

For this study, it was assumed that the present population now served by central systems will continue to be so served in the future, plus all future population increases. Conversely, the present population not served by central systems will remain constant. Since the water areas studied show increasing population, this results in an increased percentage served by central systems. This is consistent with the trend to increased urbanization and the extension of central systems to serve new areas.

Municipal Waste Loadings

Municipal waste loading estimates are based on the following assumptions:

1. The present population served by central systems plus any population increase will be served by central systems. Conversely, the population served by individual systems will remain static. This is consistent with an increasing percentage of the area population being served by central systems.

2. The raw waste load from the domestic, commercial, and public facilities on a system will equal 0.25 pounds of biochemically oxidizable material per capita per day. This amount of loading is defined as a "population equivalent" (P.E.).

3. The waste loading per capita exclusive of industrial contribution will remain constant through the study period.

ADJUSTMENT OF CALCULATED WATER SUPPLY AND WASTE LOAD VALUES

Use of the rationale described previously results in a calculated water supply and waste load value. This value will vary somewhat from observed values. Reasons for this variance can be many, including:

1. Inaccuracies in inventory values of population served and/or water use or waste loading for various systems.

2. Excessive leakage in municipal water supply systems because of poor maintenance.

3. Inefficient use of water by industry because of poor plant controls.

4. Low per capita use of water because of poor water quality or an economic level which results in lower than normal water use. In the longer term approach to the year 2000 or 2020 many of these factors should even out, and projection of current values would probably be less valid than having water use figures more nearly approach the norm.

To more accurately reflect the probable situation in the near future, the water use and waste loading values were adjusted; to accomplish this it was decided to:

1. Use the observed water use and waste load values for the current time period in the water area tables.

2. Determine the difference between the observed and calculated current values, shown as Δ_1 and Δ_2 in Figure 1.

3. Adjust the calculated 1980 values by one-half the current difference, $\Delta_1/2$ or $\Delta_2/2$, to arrive at the 1980 values in water area tables.

4. Not change the 2000 or 2020 calculated values for the reason discussed earlier in this section.

WATER SUPPLY PROGRAM

The water supply program to meet the developmental needs of Appalachia will be based on decisions reached by local, State, interstate, and Federal entities. These decisions should be based on the concept of the best multiple use of water resources for all purposes.

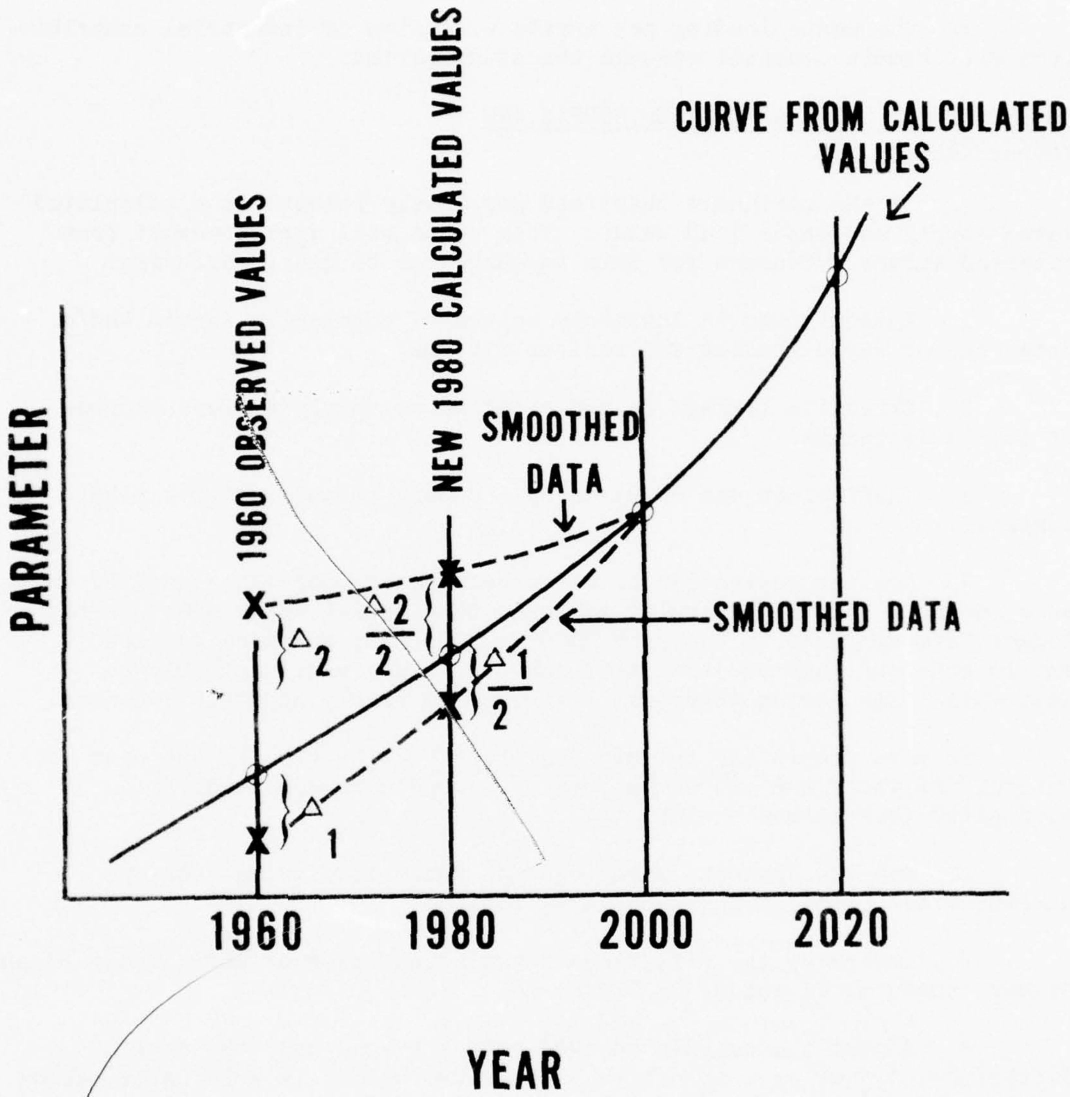

FIGURE I – WATER SUPPLY AND WASTE LOAD VALUES

Traditionally, public water supply has the highest priority of all uses where the resources are inadequate to meet all needs. Inherent in these decisions is the evaluation of alternate methods of meeting water supply and other needs. For any particular area the alternates include consideration of ground water resources, existing and developable surface water resources, importation of water from another area, and water reuse. The water area resumes are not based on detailed studies which would define the probable program for any area; however, basic factors which are inherent in each water area are considered to give a guide as to the most probable development and to indicate where more detailed studies to most satisfactorily furnish an area's needs should be undertaken.

GROUND WATER

Ground water availability and costs of development are the subject of Appendix H. This information was used in the water area resumes to evaluate broadly the potential role of ground water in meeting an area's needs.

SURFACE WATER

Surface water availability is discussed in Part II of the main report. This information, along with quality information, was used to evaluate the extent to which the water supply needs of a water area can be expected to be met from this source.

For areas where ample supplies of good quality ground or surface water do not exist at a reasonable cost, impoundment is a potential solution for an area's water supply needs. The water area resumes indicate where further evaluation of impoundment possibilities are particularly evident.

IMPORTED WATER

In areas where existing and developable ground and surface water supplies of suitable quality cannot be provided at a reasonable cost, importation from another basin is a potential means of meeting an area's needs. Because of the relatively high amount of precipitation and runoff, importation is not expected to be required to a significant extent in Appalachia. The rugged terrain in many portions of Appalachia would require pumping against a considerable static head condition which, by increasing costs, would further limit the probable development of importation of water from one basin to another.

WATER REUSE

Water reuse is a common practice in many of the areas of Appalachia, as well as in the rest of the United States. There is an increasing trend

toward in-plant reuse for major water using industries. Process, condenser, sanitary, and cooling waters may have different quality requirements. Spent water for one purpose may still be usable for a purpose requiring a lower quality.

Water reuse also exists by successive withdrawal and discharge to a stream. This is particularly common during periods of low flow. The ability to reuse water is dependent on a suitable pollution control program.

The ultimate in reuse is a closed system in which waste waters are treated to an extent to allow continued reuse with no additional water input, except for perhaps incidental make-up water. According to one study1/ cost of treating conventional municipal waste water sufficiently to regain its original quality before use approximates $0.56 per 1,000 gallons for a 10 million gallon per day renovation plant. This is approximately $0.43 per 1,000 gallons more than the conventional secondary treatment cost. This can be used as a level of cost to compare with ground water or other alternates as economic sources of supply. The cost per 1,000 gallons is dependent on the quantity being treated. For limited quantities reuse can be expected to be progressively less competitive with alternate sources.

WATER POLLUTION CONTROL

A water pollution control program has many facets. The concept of preserving water quality for legitimate uses is fundamental. Protection for various uses requires establishment of criteria for various constituents which, in excess or by a deficiency, limit uses. The most commonly used criteria establish protective levels for dissolved oxygen, temperature, dissolved solids, pH, and bacteria, the value selected being determined by the use or uses to be protected. Programs to protect waters require institutional and legal frameworks; training of personnel to operate treatment facilities; pollution abatement by in-plant control and/or treatment facilities; surveillance of quality of waters; surveillance of existing or potential pollution sources; selective discharge of effluents to waters or land, or by deep well injection; and flow regulation.

The Water Quality Act of 1965 (P.L. 89-234) provides for the establishment of Federal water quality standards for interstate waters. The States were given the opportunity to "adopt (a) water quality criteria applicable to interstate waters or portions thereof within such State, and (b) a plan for the implementation and enforcement of the water quality criteria and if such criteria and plan are established

1/ "Solving Our Water Problems - Water Renovation and Reuse," by Weinberger, Stephan, and Middleton, FWPCA, U.S. Department of the Interior.

in accordance with the letter of intent, and if the Secretary determines that such State criteria and plan are consistent with... [legislative intent]... such State criteria and plan shall thereafter be the water quality standards applicable to such interstate waters or portions thereof."

The standards applied to the waters of Appalachia can affect the development of the area. Environmental quality and water-based recreational opportunities can influence industrial location decisions. Costs of control and treatment measures to comply with the standards will also be a factor. Provision and implementation of planning on a basin-wide basis for pollution control can be an effective tool in creating both jobs and quality of the environment.

The 13 States included in the Appalachia area met a June 30, 1967, deadline for submission of standards to the Secretary of the Interior. As of April 1, 1969, interstate stream standards from all 13 States were approved in whole or in part. Those portions of the standards of the various States which were excepted from approval were, in most cases, subject to discussions and action to resolve exceptions.

WATER USES

The determination of uses to be protected is a necessary step in developing a logical pollution control program. In carrying out the purpose of the Water Quality Act of 1965, public hearings were required to allow testimony on appropriate uses prior to establishing standards. The uses generally considered for surface waters include:

Recreation and aesthetics

Public water supply

Fish, other aquatic life, and wildlife

Agriculture

Industrial water supply

Navigation

Waste assimilation

WATER QUALITY CRITERIA

The U.S. Department of the Interior established National Technical Advisory Committees to recommend appropriate criteria for all uses mentioned in Section III, "Water Uses," except navigation and waste assimilation. As

will be explained later, special criteria are generally not required for these two uses.

The Interim Report of the National Technical Advisory Committee (NTAC) was released in July 1967 and is being used for guidance in determining suitable standards.[1/] Table VIII is a synopsis of this interim report which must be used with reservation, since it is subject to many qualifications which cannot be included in a synopsis of the original report. In addition, certain water quality characteristics which are discussed in the interim report and have application in at least special instances are excluded from the exhibit.

The pollution control program, at least for interstate waters, will need to be implemented such that the appropriate uses are protected and as a consequence, so that the criteria established are met. The recommendations of the NTAC's Interim Report are briefly discussed in Section III, under "Water Quality Criteria." The interim nature of these recommendations should be recognized, as well as the fact that criteria may be revised in the future as a result of new knowledge of quality needs for protection of various uses.

The recommendations of the NTAC's report should not, however, be construed as the criteria that will apply. For interstate waters the water quality standards, as approved by the Secretary of the Interior, will contain the appropriate criteria for the various streams. Because of the concurrent development of this appendix and establishment of the standards, meaningful incorporation of the standards into this appendix was not possible.

Aesthetics and Recreation

The NTAC recommended the following requirements for aesthetics:

1. All surface waters should be capable of supporting life forms of aesthetic value. This recommendation is made in recognition of the significance of fishes, waterfowl, and other water-dependent species to human aesthetic satisfaction.

2. Surface waters should be free of substances attributable to discharges or wastes that form objectionable deposits, floating matter, odor, color, taste, or turbidity, and that are toxic or cause undesirable aquatic life.

[1/] The official report of the National Technical Advisory Committee to the Secretary of the Interior was published April 1, 1968, and was entitled "Water Quality Criteria"; it is for sale by the Supt. of Documents, U.S. Government Printing Office, Washington, D.C. 20402

Table VIII

Suggested Water Quality Requirements

I. Requirements for all waters.

A. All surface waters shall be aesthetically satisfying and shall be capable of supporting life forms of aesthetic value.

B. All surface waters shall be free of substances attributable to discharges of wastes as follows:

1. Materials that will settle to form objectionable deposits;
2. Floating debris, oil, scum, and other undesirable materials;
3. Substances that will produce objectionable color, turbidity, odor, or taste, either of itself or in the biota;
4. Materials, including radionuclides, in concentrations or combinations which directly or indirectly are toxic or will induce undesirable physiological responses in humans, fish, and other animal life, and in plants;
5. Substances and conditions or combinations thereof in concentrations which will induce undesirable aquatic life.

II. Requirements for specific uses.

Parameter / Use	Temperature	D.O.	Bacteria	pH	Toxic Materials	Others
Fresh water organisms & wildlife	I. Warm water fishery (bass, crappie, catfish) A. No more than 5°F above natural. B. Following extremes not to be exceeded: 1. Northern: max 83-86°F 2. Central: max. 86-90°F 3. Southern: max 90-96°F II. Cold water fishery (trout, salmon) A. No warming B. In spawning areas and seasons: max 55°F	I. Warm water fishery: min. >5 ppm; occasionally 4 ppm II. Cold water fishery: A. Passage & maintenance: min. >6 ppm; occasionally 5 ppm B. Spawning: min >7 ppm		6.0-9.0	Bioassay: 1. Acute exposure 1/10 of 48 hr TL_m 2. Chronic exposure 1/100 of 48 hr TL_m	
Public water supply			1. Desirable: Total coliform 100/100 ml Fecal coliform 20/100 ml 2. Permissible: Total coliform 10,000/100 ml Fecal coliform 2,000/100 ml		See narrative in "Public Water Supply," page D-30	A. TDS Desirable: <200 Permissible: <500 B. Chlorides Desirable: <25 Permissible: <250 C. Sulfates Desirable: <50 Permissible: <250
Recreation			1. Primary contact: Mean fecal coliform content not over 200/100 ml; not more than 10% of samples with fecal coliform over 400/100 ml. 2. Sec. contact: Mean fecal coliform content not over 1,000/100 ml; not more than 10% of samples with fecal coliform content of 2,000/100 ml.			
Agriculture	Basic requirements will satisfy agricultural needs.					
Industrial water	Basic requirements will satisfy industrial needs.					

The recommended requirements for recreation are:

1. For waters not involving significant risks of human ingestion, the fecal coliform level should not exceed 2,000 per 100 ml in more than 10 percent of the samples, nor exceed a geometric mean of 1,000 per 100 ml. Fishes, waterfowl, and other aquatic life should be available for human enjoyment and consumption.

2. For waters designated for primary contact recreation, the fecal coliform level should not exceed a geometric mean of 200 per 100 ml, nor exceed 400 per 100 ml in more than 10 percent of the samples for a 30-day period. The pH should be within the range of 6.5 to 8.3, except when caused by natural causes, but in no case should it be less than 5 nor more than 9.0.

Public Water Supply

The NTAC recommended the following requirements for untreated water prior to conventional treatment for public water supply use.

Constituent or Characteristic	Permissible Criteria	Desirable Criteria
Physical		
Color	75 (color units)	<10 (color units)
Odor	None that cannot be removed by conventional treatment	
Microbiological		
Coliform organisms	10,000/100 ml	< 100/100 ml
Fecal coliforms	2,000/100 ml	< 20/100 ml
Inorganic		
Alkalinity	30-500 mg/l	---
Ammonia	0.5 (as N) mg/l	< 0.01
Chloride	250 mg/l	< 25
pH	6-8.5	---
Organic Chemicals		
Carbon chloroform extract	0.15 mg/l	< 0.04
Methylene blue active substance	0.5 mg/l	virtually absent

The recommended permissible values for the following constituents are essentially the same as the values recommended by the U.S. Public Health

Service Drinking Water Standards:[1/] arsenic, barium, cadmium, chromium, copper, fluoride, iron, lead, manganese, nitrates, selenium, silver, total dissolved solids, zinc, cyanide, phenols, and radioactivity. The desirable values recommended by the NTAC for these constituents are absence or virtual absence in public water supplies.

Fish, Other Aquatic Life, and Wildlife

The NTAC recommended the following limits on constituents for wildlife and freshwater organisms:

Constituent or Characteristic	Limit
Dissolved solids	$\leq$ 1/3 over natural concentration $\leq$ 50 miliosoles
pH	6-9
Temp. (warm water fishery)	$\leq 5^{\circ}$ above ambient; max. temp. depends on area
Alkalinity	$\geq$ 20 mg/l
Temp. (cold water fishery)	No increase over ambient; max. winter, 55° F.
Oxygen (warm water)	5 mg/l*
Oxygen (cold water)	5-7 mg/l
CO_2 (free)	$\leq$ 25 mg/l
Oil	No color, film, odor, tainting, of fish, toxicity
Turbidity	Stream (warm) $\leq$ 50 Jackson units Stream (cold) $\leq$ 10 " " Lakes (warm) $\leq$ 25 " " Lakes (cold) $\leq$ 10 " "
Floating materials	None of foreign origin
Tainting substances	None
Radioactivity	None
Plant nutrients	Carefully controlled, no oxygen decrease, no radical change in nitrogen to phosphorus ratio
Toxic materials	$\leq$ 1/10 of 96 hrs TL_m

[1/] U.S. Department of Health, Education, and Welfare. 1962 Public Health Service Drinking Water Standards. PHS Publication No. 956. U.S. Government Printing Office, Washington, D.C. 20402.

*Under extreme conditions the dissolved oxygen concentrations may range between 4 mg/l and 5 mg/l provided that the water quality is favorable in all other respects.

Agricultural Uses

Generally this use is protected by the criteria limitations imposed by other uses which require a higher quality water, such as aquatic life and public water supplies. The recommended requirements by NTAC for irrigation use are generally not applicable to the relatively high rainfall Appalachian area, where irrigation, if practiced at all, is supplemental in nature.

Industrial Uses

Industrial uses are generally protected by criteria for other uses which require a higher quality water, such as aquatic life and public water supplies. For many States minimum conditions establishing aesthetic conditions applicable to all waters were considered suitable for protecting industrial use. Water quality needs for industry vary considerably by type of industry. Quality beyond the basic level established by minimum conditions may require in-plant treatment for those industries with special quality needs.

For standards purposes, many States considered public water supply criteria applicable for those industries engaged in food processing.

Navigation and Waste Assimilation

These are legitimate uses for many waters in Appalachia. Water quality criteria for these uses were not formulated. Minimum conditions for all waters established by many of the States would require no special criteria for these uses.

IMPLEMENTATION AND ENFORCEMENT OF WATER POLLUTION CONTROL

Implementation and enforcement of water pollution control requires application of existing technology and development of new technology to provide answers to control of present pollutants and additional pollutants in quantity and type. The technological advancement of an industrial society is the source of both greater volume of conventional pollutants and new potential pollutants from development of new processes and new industrial and consumer products. Equally important is providing trained personnel to plan, construct, and operate pollution control facilities. Underlying the basic thrust in pollution control is the provision of adequate laws and institutional arrangements to efficiently mobilize the various human and material resources into an effective program to meet Appalachian and national needs.

Control Methods

Various alternate methods exist for control of pollution. Depending on the pollutant of concern and the circumstances uniquely applicable in a specific situation, one or another type of control, or combination of controls, will be favored. Table IX lists for various types of pollutants the type of control methods that would generally be favored.

Source Control

The term, "source control," as used in this appendix describes process change or refinement to reduce quantities of pollutants. Also included in the definition of this term is the conversion of potential pollutants into useful products or by-products. An example of such source control is the improvement in thermal efficiency of thermal electric power plants. As a greater proportion of thermal energy is converted into useful electrical energy, a lesser amount of waste thermal energy per unit of power production is discharged into the environment. Another example is the development of a wet oxidation treatment process (Copeland-Container process) for the treatment of sulfite liquor for the pulp industry. An end product of this treatment process is calcium sulfate, which on recovery, can be used at pulp mills using the sulfate process.

The increased employment indicated by benchmark goals, along with projected productivity increases, results in large increases in projected industrial production over present levels. Source control methods can be expected to be an important element in protection of Appalachia's water resources.

Waste Collection

Basic to protection of the environment is collection of wastes such that community health is protected. This study assumes liquid wastes are effectively collected and transmitted to waste treatment plants. A major problem in some areas is that resulting from storm water runoff. A common collection system for storm water runoff and sanitary wastes contributes to the water pollution problem. Present policies are to provide separate facilities for storm water runoff and sanitary wastes in new construction. A research and demonstration grant program of FWPCA is now under way to provide a better insight into possible methods of separation, treatment, or other means of collecting and controlling such wastes.

Table IX

Type of Waste	Control Methods					
	In-plant Control 1/ (Control at Source)	Off-stream Treatment 2/	Deep Well Injection	Secondary Treatment	Advanced Waste Treatment 3/	Flow Regulation 4/
Industrial						
Plating & other toxic	P	S	S			
Biodegradable organic	P			P	S	S
Nonbiodegradable organic	P		S		P	
Coal fines		P				
Mine drainage	P	S				S
Thermal	P	P				S
Brine wastes (oil field)			P			
Nonorganic dissolved solids	P		P		P	S
Taste & odor producing substances	P				P	
Bacterial		P				
Municipal						
Biodegradable organic				P	S	S
Bacterial		P				

P - Primary control methods
S - Secondary control methods
1/This includes product recovery, process control to eliminate discharge of pollutants and for mine drainage sealing, diversion of runoff from pyritic materials and submersion or covering of pyritic materials.
2/This includes neutralization, chlorination, and other common chemical processes which alter pollutants to a nonobjectionable state and sedimentation either with or without chemical addition.
3/This includes processes not commonly used at present including reverse osmosis, electrodialysis, distillation, carbon filtration, and foam separation.
4/This includes augmentation of streamflow from impounded water and impoundment of wastes until discharge is possible at a time when effect on water quality is minimal.

Waste Treatment

Conventional waste treatment measures for municipal wastes include:

1. Screening and sedimentation of solids wastes.

2. Digestion, incineration, or filtration of sludges.

3. Biological treatment of primary effluents.

4. Disinfection of effluents.

Conventional treatment measures for industrial wastes include, in addition to those for municipal wastes:

1. Neutralization.

2. Flotation.

3. Chemical precipitation.

4. Chemical oxidation-reduction and other reactions to convert pollutants to a nonpollutional form (such as chlorination for conversion of cyanides to nontoxic chemical forms).

For biodegradable municipal and industrial wastes, primary (removal of settleable solids) and secondary (biological treatment) treatment phases or equivalent treatment are defined as adequate treatment. For evaluation purposes this degree of treatment is considered capable of 85 percent removal of the 5-day biochemical oxygen demand (BOD).

The estimated cost of upgrading treatment to the level of secondary for those communities discharging untreated wastes or those providing less than secondary treatment is $275,000,000. This is exclusive of construction of collection and interceptor sewers and pump stations. Costs are those current in early 1967. This volume of construction would provide secondary treatment for all communities by approximately 1972 or earlier where so planned. The annual average investment for secondary treatment at the early 1967 cost level after this period is estimated at $25,000,000. A subregion breakdown of estimated costs to initially provide complete secondary treatment is shown below in millions of dollars:

A - 33	F - 84
B - 67	G - 27
C - 0.7	H - 1.5
D - 7	I - 3
E - 35	J - 15

Should this level of treatment be insufficient to protect legitimate uses, measures beyond secondary treatment are considered and evaluated on a case-by-case basis. These measures may include flow regulation or supplemental treatment for the removal of additional solids, organics, nutrients, or minerals. Often supplemental treatment can be provided without construction of additional treatment units. Examples include polyelectrolyte treatment in the primary settler for improved solids removal or mineral addition to the aerator for improved phosphate removal.

Tertiary or third-stage treatment may be required depending on effluent quality criteria. Tertiary treatment processes, grouped according to type of contaminant removed, include:

1. Suspended solids

    a. Screening

    b. Coarse media filtration

2. Phosphate

    Alum or lime clarification with dual media filtration.

3. Organics

    a. Granular carbon adsorption

    b. Powdered carbon adsorption

4. Dissolved solids

    a. Electrodialysis

    b. Reverse osmosis

    c. Ion exchange

The Advanced Waste Treatment Branch of the FWPCA is conducting basic research and pilot plant investigations to determine the costs

of these and other tertiary treatment techniques, to improve treatment efficiencies and to find solutions to the operating problems that may arise in the use of these methods.

Treatment technology is currently available to provide almost any degree of treatment, ranging from effluent polishing to the production of potable water. Figure 2 1/ shows a complete renovation system incorporating selected tertiary treatment processes. This flow sheet represents only one possible treatment sequence. Operating costs will vary with plant sizes; therefore, costs for smaller installations will exceed the indicated values.

The indicated cost is for a 10 million gallon per day treatment plant receiving a typical municipal waste. The cost including plant amortization is $0.43 per 1,000 gallons in excess of conventional secondary treatment costs. This cost for reuse can be compared with other potential sources of municipal water supply. A fair comparison should include costs of source development and transmission where necessary and treatment required for potability. For uses requiring a lesser quality of water, such as for some industrial water supply purposes, a lesser cost for advanced waste treatment would be appropriate for direct-use comparison. In addition, where the effluent is discharged to a stream and water quality is not adequately protected by secondary treatment, something less than complete renovation may be an alternate to other possible pollution control measures.

Effluent Discharge

A water pollution control program in an area may consider several alternates in discharge of effluents. Included are discharge to one or another of the surface waters of an area, discharge on the land, or discharge to suitable subsurface geological formations.

The surface waters of an area are the most commonly utilized to receive the discharge of municipal and industrial effluents. In some instances pumping effluents to an adjacent basin may serve to best protect water resources by protecting unique water quality values or where insufficient dilution water exists in the basin in which an effluent originates. In much of Appalachia the terrain would require a considerable pumping head to discharge over a drainage divide to another basin.

Discharge of effluents on the land is practiced for some effluents. Generally, this is most advantageous in arid and semi-arid areas where

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1/ "Solving Our Water Problems, Water Renovation and Reuse," Weinberger, Stephan, and Middleton, FWPCA, U.S. Department of the Interior.

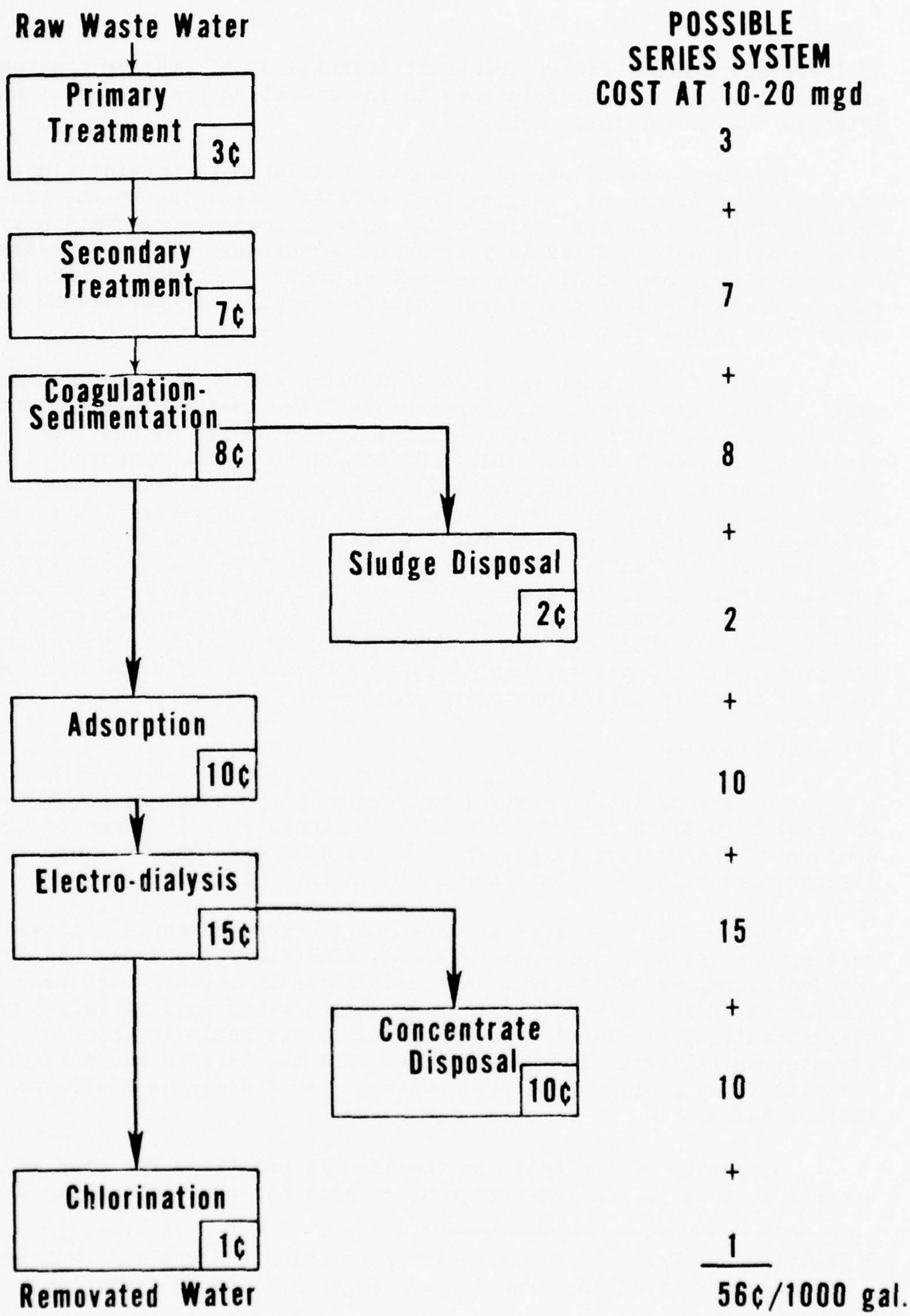

FIGURE 2 GENERALIZED WATER RENOVATION SYSTEM, SERIES FLOW

water is a premium commodity and where water-logging of the soil will not occur. A relatively flat or gently rolling terrain is also generally advantageous. In Appalachia the high rainfall and steep terrain hinder extensive use of this discharge method. In certain specialized instances this method of discharge may be advantageous and should not be overlooked.

The most desirable method for disposing of oil field brines is to return them to a deep underground geologic horizon, either the one from which they were removed originally, or another similar horizon. Underground disposal is also applicable to small volumes of industrial wastes that are difficult to treat or highly pollutional. Deep-well industrial waste disposal is expected to be increasingly used as pollution control is enforced and the technology of underground disposal is advanced. A study should be made to determine the extent to which deep-well disposal of wastes may be technically feasible in Appalachia and to recommend criteria and procedures for regulation of such disposal.

Flow Regulation

Flow regulation as used in this appendix is defined as a modification of streamflow or waste discharge to produce the minimum detrimental effect on water uses. This includes storage of dilution water or storage of wastes for release at a more advantageous time. Storage of effluents after secondary treatment is sometimes used as a polishing treatment where higher than normal treatment measures are indicated. For nonbiodegradable wastes, storage acts to allow discharge at such time as minimum detrimental effect will result to water uses. Storage of water for later flow augmentation is generally not considered suitable for control of bacterial pollution or for toxic materials which should be removed by treatment. Storage of water for later flow augmentation to assimilate residual biodegradable wastes (after secondary or higher degrees of treatment) is evaluated on a project-by-project basis for federally constructed reservoirs under provisions of the Federal Water Pollution Control Act.

Personnel and Training Needs

The Federal Water Pollution Control Administration has conducted a study resulting in a report entitled "Manpower and Training Needs in Water Pollution Control."[1/] This study assessed national needs for trained personnel for water pollution control accruing from recent acceleration in construction rates of municipal and industrial waste plants, and projected acceleration resulting from 1965 and 1966 amendments to the Federal Water Pollution Control Act.

1/ Senate Document No. 49, 90th Congress, 1st Session, August 2, 1967.

The needs for more trained personnel accrue not only from additional construction of waste treatment facilities, but also from more complex installations requiring more highly trained operating staff. The acceleration produces demands for personnel by consulting engineers, State agencies, municipalities, and industry. Table X shows manpower requirements, based on an estimate that 10 percent of the national needs can be ascribed to the Appalachian area. Other conclusions derived from the referenced study include:

1. Mandatory licensing of sewage treatment plant operators on the basis of demonstrated efficiency has the combined effects of improved plant operations and improved employee status. The following States, all or partially in the Appalachian area, have such licensing requirements: Kentucky, Maryland, New York, Ohio, West Virginia, and Pennsylvania.

2. "A cooperative government-wide education and training program should be developed which will make full use of other federally assisted programs for developing professional and vocational schools."[1] For the Appalachian area, FWPCA, cooperating with the States and the Department of Health, Education, and Welfare, should investigate the educational opportunities provided in the Appalachia Regional Development Act as well as other opportunities to meet training needs for water pollution control.

Legislation

To conduct a more effective pollution control program the following legislation is considered desirable:

1. Legislation and funding to allow communities to take advantage of the more liberal grant provisions of the 1966 amendments to the Federal Water Pollution Control Act. These amendments allow a Federal grant up to 55 percent of the eligible portions of municipal waste treatment facilities contingent on a State grant of 25 percent of the eligible portion. Among the 13 Appalachian States, only the States of New York and Maryland have provisions for this level of State participation at this time.

2. Federal Water Pollution Control Administration officials in cooperation with the Association of State and Interstate Water Pollution Control Administrators developed a "Suggested State Water Pollution Control Act" in November 1965. This is a consensus of desirable elements in a State act to control water pollution. The various States should review their present legislative provisions and where pollution control cannot be adequately carried out, revisions or a new act should be formulated.

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[1] Senate Document No. 49, 90th Congress, 1st Session, August 2, 1967.

Table X

Estimates of Manpower Requirements
for Appalachia Area

Employers	Fiscal Year, 1967			Fiscal Year, 1972								
	Profes-sionals	Tech-nicians	STP Operators	Professionals Est.	Professionals Inc.	Professionals % Inc.	Technicians Est.	Technicians Inc.	Technicians % Inc.	STP Operators Est.	STP Operators Inc.	STP Operators % Inc.
State Agencies	140	30	-	340	200		100	70		-	-	
Local Agencies	225	225	2,000	550	325		550	325		3,000	1,000	
Subtotal	365	255	2,000	890	525	145	650	395	150	3,000	1,000	50
Indus. Waste Treatment	170	170	350	600	430	253	600	430	253	1,200	850	243
Consulting Engineers	600	600	-	2,100	1,500	240	2,100	1,500	250	-	-	-
Total	1,135	1,025	2,350	3,590	2,455	215	3,350	2,325	225	4,200	1,850	80

3. As indicated in Section III, mandatory certification of sewage treatment plant operators is considered a method of improving water pollution control. Those States not now requiring such certification should consider changes to include this requirement.

4. Since the basic planning and implementation of water quality control should logically be conducted by a river basin approach, more basin compacts can be expected. Legislation to allow this type of interstate cooperation should be provided where and as the need arises.

Regardless of present legislative adequacy of the various States, laws should be reviewed periodically to determine what changes might be desirable to better implement water pollution control. Some of these may result from changing needs or to take better advantage of provisions of Federal legislation. The best way to ensure adequate laws is by having the water pollution control agencies of the States communicate their legislative needs to the public and legislators.

Institutions

"Within the creative federalism that has become a distinguishing characteristic of the Governmental structure of the United States, the responsibility for managing the water and related land resources of the Nation's river basins is shared among Federal, State, and local governments and private enterprises.

"To avoid clashes among these separate efforts and to enable them to contribute to the harmonious development of river basin resources, institutional arrangements are needed to facilitate the participation of all the operating agencies in a responsible management structure. A number of such arrangements have grown up and each of them has some strengths and some weaknesses. As the pressures upon river basin resources increase, more sophisticated mechanisms may be required for these purposes."[1/]

The design of institutional arrangements for river basin mangement is of obvious value in the development of a long-range program for the management of water supply and pollution control. However, the goal of the Appalachian resource study is the development of a short-range action program, whose implementation will depend, of necessity, upon the existing institutions.

The five FWPCA Regions involved in this study will be working within the existing institutional framework in an effort to improve the management of water supply and pollution control. The FWPCA will continue to cooperate with existing interstate, State, and local

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[1/] Stewart L. Udall, Alternative Institutional Arrangements for Managing River Basin Operations, Water Resources Council, August 1967.

governments as it establishes new lines of communication, strengthens existing ones, and improves the coordination of mutually supporting activities. The geographical boundary of the study area neither coincides with FWPCA regional boundaries nor with river basin boundaries, and thus coordinating activities are somewhat complicated. However, a healthy recognition of this complexity is the first step in its management.

For the purposes of this study, it is sufficient to recognize that short-range programs will rely, primarily, upon existing institutions for their implementation. However, institutional design should be included in the development of any long-range resource management program for the Appalachian region.

WATER QUALITY PROBLEMS

Water quality problems for each water area are discussed in the individual water area resumes and in the project reports, Sections IV and V, respectively. One method of grossly assessing the existence of water quality problems is a record of fish kills in an area. In the following paragraph a summarization of reported fish kills for 1966 is presented for the Appalachian study area.

Reported Fish Kills in Appalachia in 1966

Table XI is extracted from "Fish Kills by Pollution, 1966, Seventh Annual Report, FWPCA." This tabulation reflects a reported 9,115,000 fish killed in the United States and about 3,000,000 in Appalachia. Mining and food and kindred products operations were responsible for the majority of the reported fish killed in Appalachia in 1966. Most of the fish reported killed by mining in the U.S. can be attributed to occurrences in Appalachia. The fish killed by food and kindred products operations in Appalachia were almost completely caused by one incident; therefore, the 1966 percentage figure for this one catefory may not be representative of what would be the distribution in most years. Agricultural operations were a considerably lesser relative cause of fish kills in Appalachia in 1966 than in the nation as a whole.

Table XI

Fish Kill Summary by Source of Pollution

Operations	% Distribution of Fish Killed in Appalachia	% Distribution of Fish Killed in U.S.	% of U.S. Fish Killed Occurring in Appalachian Area	Frequency Appalachia	Frequency U.S.
Agricultural Operations					
Poison (Pesticides, Herbicides, etc.)	0.14	2.4	1.9	3	44
Manure, Silos, Feed	0.19	11.4	0.5	3	34
Industrial Operations					
Mining	45.31	15.9	91.2	16	27
Food & Kindred Products	26.96	19.7	43.7	4	31
Paper & Allied Products	0.27	0.14	60.0	4	8
Chemicals	0.48	7.9	2.0	4	28
Petroleum	1.13	1.7	21.2	3	16
Combinations	2.45	1.0	75.3	2	7
Other	7.11	4.5	50.5	11	34
Municipal Operations					
Sewerage Systems	4.16	14.1	9.4	8	64
Water Systems	0.01	.08	5.7	1	7
Transportation Operations					
Rail	0.04	0.14	7.8	1	6
Truck	0.85	0.72	37.2	6	11

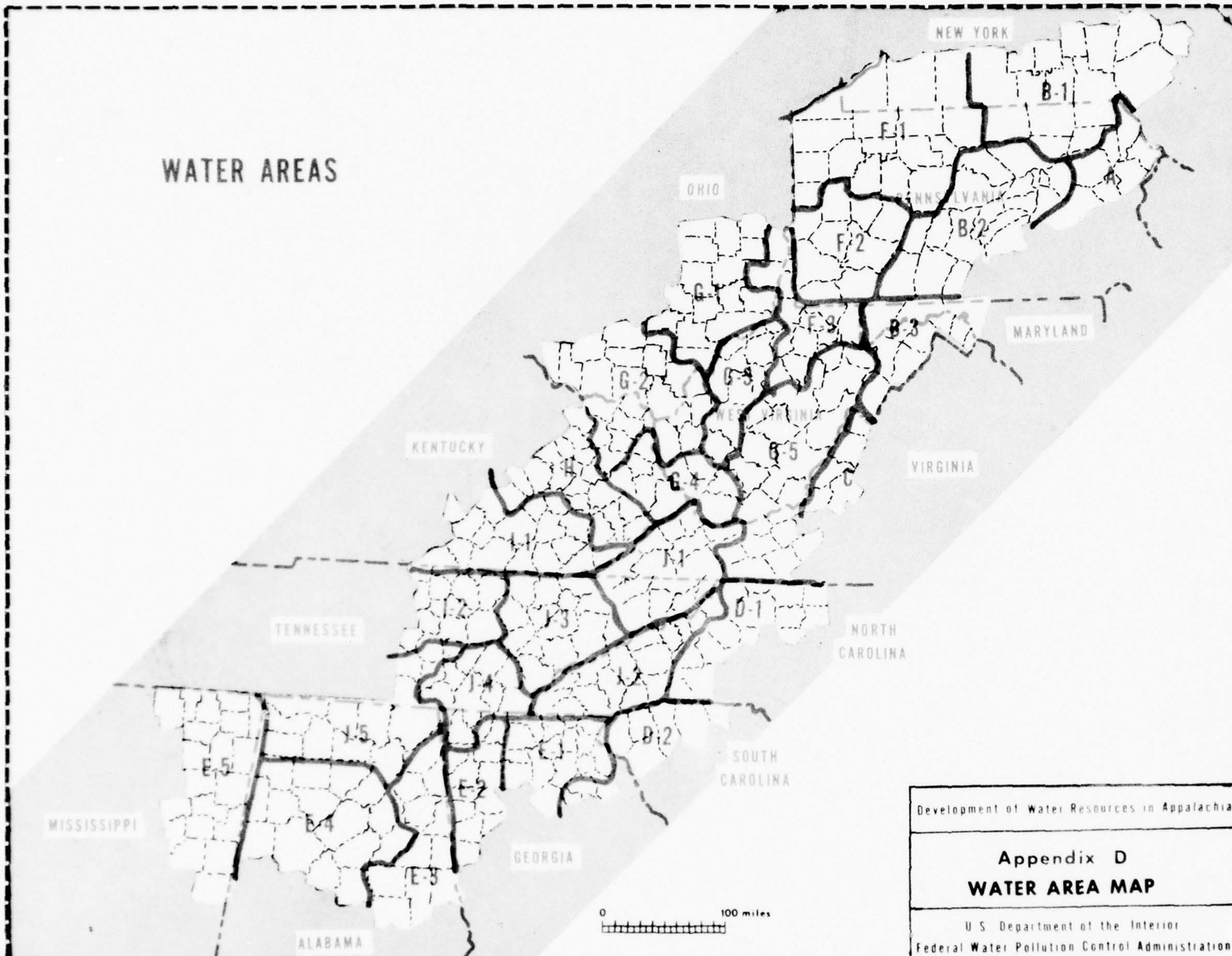
Fish Kill Summary by Source of Pollution

Operations	% Distribution of Fish Killed in Appalachia	% Distribution of Fish Killed in U.S.	% of U.S. Fish Killed Occurring in Appalachian Area	Frequency Appalachia	Frequency U.S.
Other Operations	7.21	15.5	14.9	5	30
Unknown	3.69	4.1		9	95

31.9% of the reported fish killed in the U.S. were from kills in Appalachia

SECTION IV - WATER AREA RESUMES

WATER AREAS



Development of Water Resources in Appalachia

Appendix D

WATER AREA MAP

U.S. Department of the Interior

Federal Water Pollution Control Administration

WATER AREA A RESUME

WATER SUPPLY REQUIREMENTS

Present

The current needs (see Table A) are being met predominately from surface sources requiring conventional treatment prior to municipal use. About 70 percent of the municipal and industrial water use in water area A is in the Scranton and Wilkes-Barre Standard Metropolitan Statistical Areas (SMSA).

Future

Generally, sufficient water is available to meet the water supply needs on an area-wide basis if water quality programs are successful. The Scranton area is expected to outgrow its present water supply sources; however, insured flows in the Susquehanna River should be sufficient to meet the area's needs. Studies of ground water in Subregion A should continue to be expedited and the role of ground water in meeting the water needs defined in an integrated plan of surface ground water management.

Release of water from storage in reservoirs in water area A as well as from other portions of Appalachia can serve to prevent intrusion of saline water up the Delaware Estuary to the Philadelphia water intake during extreme low-flow periods.

WATER POLLUTION CONTROL

Water Quality Problems

The streams of Subregion A are affected by a variety of problems affecting water quality. Foremost of these are mine drainage, inadequately treated municipal and industrial wastes, nutrient concentrations and sediment problems.

Mine drainage is a problem in the counties of Lackawanna, Luzerne, Carbon, and Schuylkill. Major streams affected by mine drainage include the Susquehanna, Lackawanna, Lehigh, and Schuylkill Rivers. (For more detail on this pollution problem see Appendix C.)

Inadequately treated municipal and industrial wastes degrade the Lackawanna River and cause bacterial pollution problems in portions of the water area.

Nutrient enrichment causing algal blooms is a problem in lakes and reservoirs in Wayne, Pike, and Monroe Counties and is a potential problem in the Tocks Island Reservoir.

Sediment from mine drainage sources and from agricultural runoff affect many streams. For the Schuylkill River sediment from such sources contribute to an approximately one-half million dollar annual maintenance dredging program.

Water Pollution Control Program

Provision of secondary treatment with effective disinfection and an equivalent level of treatment for industrial wastes should provide adequate levels of dissolved oxygen for most streams in the water area. Significant growth in the Scranton area would require that additional measures such as flow augmentation and advanced waste treatment be considered to protect the Lackawanna River. Measures to protect waters of the area include a trunk line sewerage system for the Tocks Island area to reduce pollution in Pike and Monroe Counties. The Beltzville Reservoir under construction has storage allocated to water quality control for the Lehigh River in the Carbon County area.

Acid pollution control measures under way include a chemical neutralization plant on the Lackawanna River, 2 miles above the confluence with the Susquehanna River in Luzerne County. (For greater detail on mine drainage pollution control see Appendix C.)

Nutrient enrichment problems are expected to increase and programs for control of nutrients will be necessary to protect the waters of the area. These programs will require planning and control from municipal, industrial, and agricultural sources.

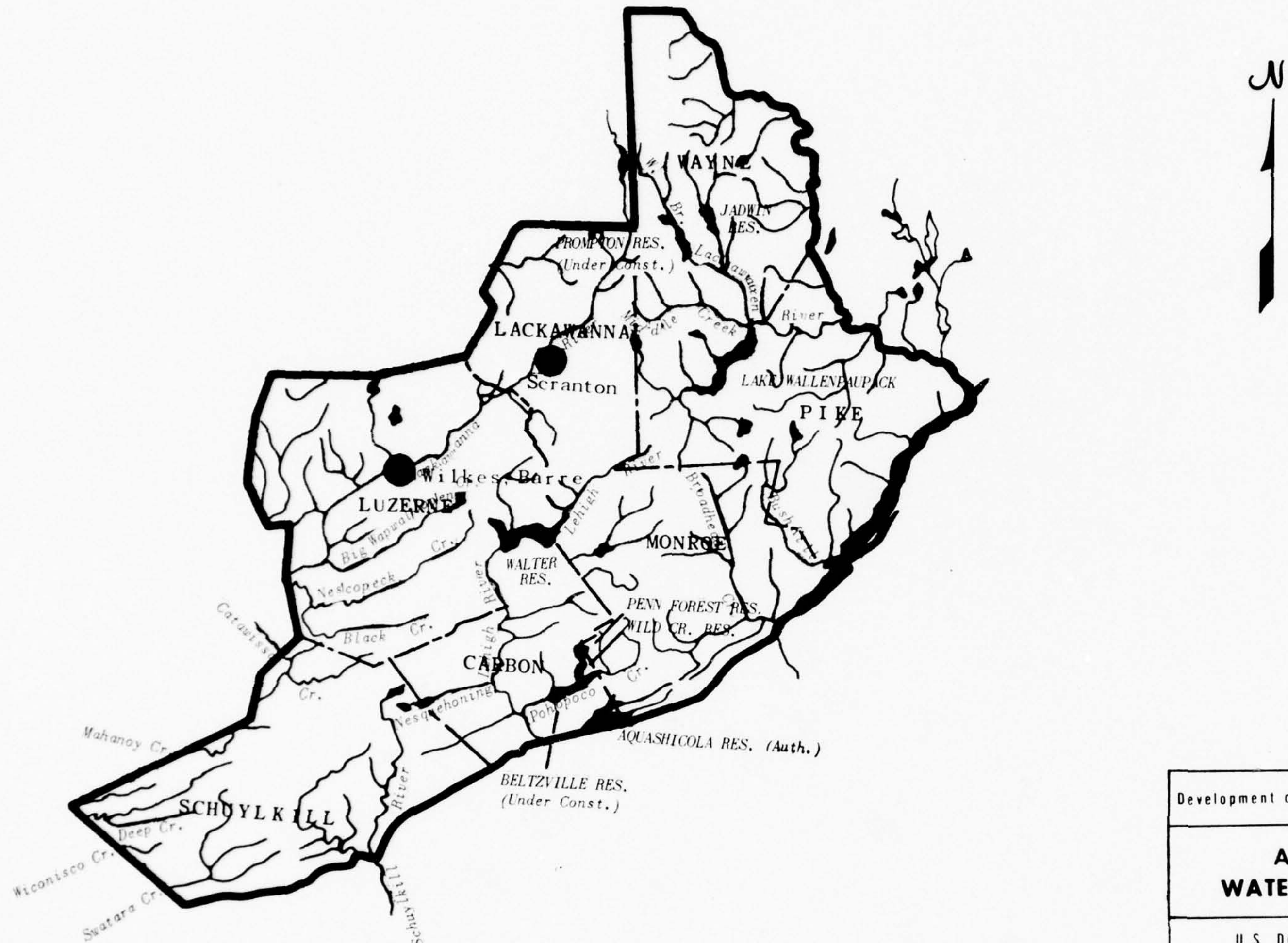
Table A

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to Meet Benchmark Goals

1960	1980	2000	2020
160	280	550	920

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
770	970	1650	2650



Development of Water Resources in Appalachia

Appendix D
WATER AREA A MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

WATER AREA B-1 RESUME

WATER SUPPLY REQUIREMENTS

Present

In water area B-1 water use by municipalities and industries is concentrated in Binghamton, New York, and the many moderate-sized communities in the area. Present municipal and industrial water use in shown in Table B-1. Drilled wells and the Susquehanna and Chemung Rivers are the principal sources of municipal and industrial water supply in the area.

Future

Future water supply needs and possible alternatives for meeting these needs are currently being evaluated by a comprehensive study of the Susquehanna River Basin. Preliminary findings of this study indicate that with proper development, surface and ground water resources will adequately meet projected 2020 water supply needs in the area.

WATER POLLUTION CONTROL

Water Quality Problems

The water quality in some reaches of the major stream within the area is degraded to the extent that the beneficial use of the stream is severely limited. The degradation of water quality is caused primarily by the discharge of inadequately treated municipal wastes. As a result of inadequately treated wastes, a 20-mile reach of the Susquehanna River below Binghamton, New York, is one of the most degraded reaches of stream within the entire Susquehanna River Basin. Localized pollution problems exist downstream from the many moderate-sized communities in the area. Mine drainage causes a major pollution problem in the upper reaches of the Tioga River. Mine drainage pollution, originating in the small headwater tributaries, adversely affects over 36 miles of the Tioga River. Pollution associated with excessive nutrient loadings are a problem in inland lakes and reservoirs, especially Cayuga and Seneca Lakes. Present municipal and industrial waste loadings in the area are shown in Table B-1.

Water Pollution Control Program

None of the existing reservoirs in the area has storage allocated to water quality control. Projected future waste loadings and assimilation studies conducted during the course of the comprehensive study of the

Susquehanna River indicate that higher levels of waste treatment, in-plant process waste control, flow augmentation, and, in some cases, waste diversion should be considered in order to achieve desirable stream uses.

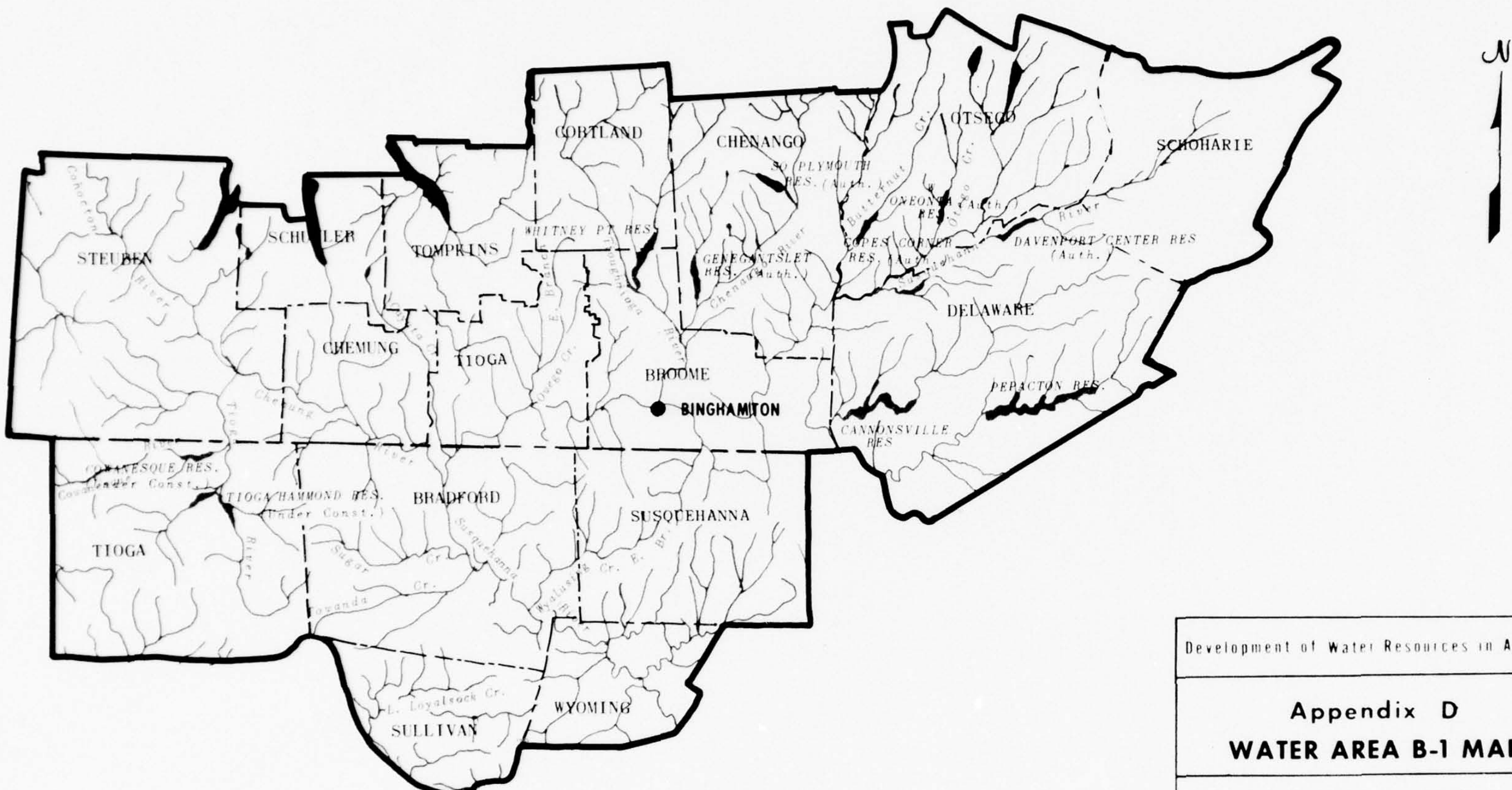
Table B-1

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
152	250	470	910

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
641	1400	2700	5050



Development of Water Resources in Appalachia

Appendix D

WATER AREA B-1 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA B-2 RESUME

WATER SUPPLY REQUIREMENTS

Present

Present municipal and industrial water supply use is predominantly concentrated in the Altoona and Johnstown SMSA (Standard Metropolitan Statistical Area) and the moderate-sized communities throughout the area. The major use of industrial process water is in the manufacture of chemicals and paper products. The largest single industrial water use of approximately 25 mgd is by the Merck and Company chemical plant in Northumberland County. Present municipal and industrial water uses are shown in Table B-2.

Future

Generally, municipal and industrial water supply requirements in the area for the year 2020 can be met by developing existing surface and ground water resources. However, the Altoona and Tyrone areas in the headwaters of the Juniata River Basin are expected to experience serious water supply problems in the future. In the case of Altoona, it may be necessary to consider water import from other basins or the complete treatment and reuse of water in order to meet anticipated water supply demands.

WATER POLLUTION CONTROL

Water Quality Problems

Because of the relative large volume of flow in the major streams of area B-2, current municipal and industrial waste discharge practices do not seriously restrict most beneficial usage of the major streams. However, localized pollution problems do exist immediately downstream from some municipal and industrial discharge points. Pollution problems, mainly associated with industrial discharges, currently occur in North Bald Eagle Creek and West Branch in the vicinity of Lock Haven, Pennsylvania; West Branch Susquehanna River near Milton, Pennsylvania; and the Susquehanna River below Danville, Pennsylvania. The water quality in several tributary streams is continuously degraded by mine drainage pollution, and, during periods of high tributary runoff, the waters in the main stems of the Susquehanna and West Branch are subject to intermittent degradation from "slugs" of mine drainage pollution. Present municipal and industrial waste discharges are shown in Table B-2.

Water Pollution Control Program

Studies based on municipal and industrial waste load projections developed by the Middle Atlantic Region indicate that in order to maintain the desirable water use in the major streams in area B-2, consideration should be given to upgrading current municipal and industrial waste treatment practices, in-plant process waste improvement, and flow regulation for water quality control. The multipurpose Blanchard Reservoir Project, now under construction in the North Bald Eagle Creek Basin, could possibly supply some of the low-flow augmentation needed in the Lock Haven Area.

For further detail on mine drainage control needs see Appendix C.

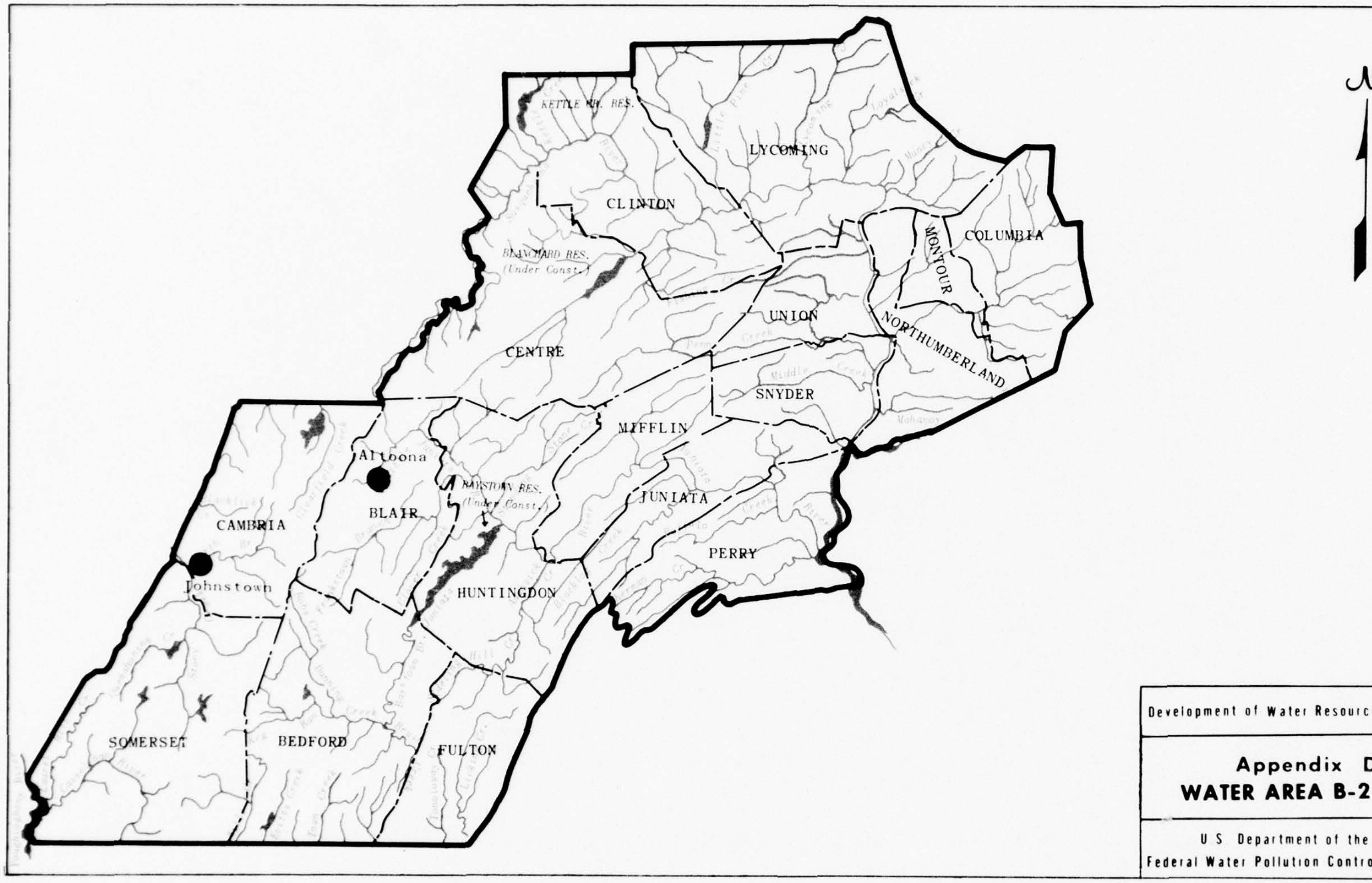
Table B-2

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
223	455	780	1230

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
2685	3700	5650	9800



Development of Water Resources in Appalachia

Appendix D
WATER AREA B-2 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA B-3 RESUME

WATER SUPPLY REQUIREMENTS

Present

In water area B-3 water use by municipalities is dispersed between the many small- to moderate-sized communities throughout the area. The largest use of industrial water is associated with the manufacture of chemical and paper products in the North Branch of the Potomac River. Present municipal and industrial water uses are shown in Table B-3.

Future

The surface and ground water resources of the area appear to be adequate to meet future water supply requirements. In the North Branch Basin the increase in dependable flow provided by the authorized Bloomington Reservoir Project will meet anticipated industrial and municipal water supply needs through the year 2020.

WATER POLLUTION CONTROL

Water Quality Problems

The most widespread pollution problem in the area is associated with mine drainage discharge which adversely affects the water quality of the North Branch Potomac River from its headwaters to the mouth. Because of inadequate treatment practices, localized pollution problems exist below many municipal and industrial waste discharge points. Pollution problems associated with municipal and industrial waste discharges occur in the North Branch below Luke, Maryland, Amcelle, Maryland, and Cumberland, Maryland. Present municipal and industrial waste loadings are shown in Table B-3.

WATER POLLUTION CONTROL PROGRAM

The U.S. Army Corps of Engineers has been authorized to construct a multipurpose dam on the North Branch Potomac River at Bloomington which will beneficially affect the downstream water quality. Based on the projection of future waste loadings in the North Branch, studies indicate that the increase in dependable flow supplied by the Bloomington Reservoir Project, coupled with adequate treatment, will provide a water quality in the North Branch which will support most beneficial uses, contingent upon the solution to the mine drainage problems.

For further detail on mine drainage problems and possible control measures see Appendix C.

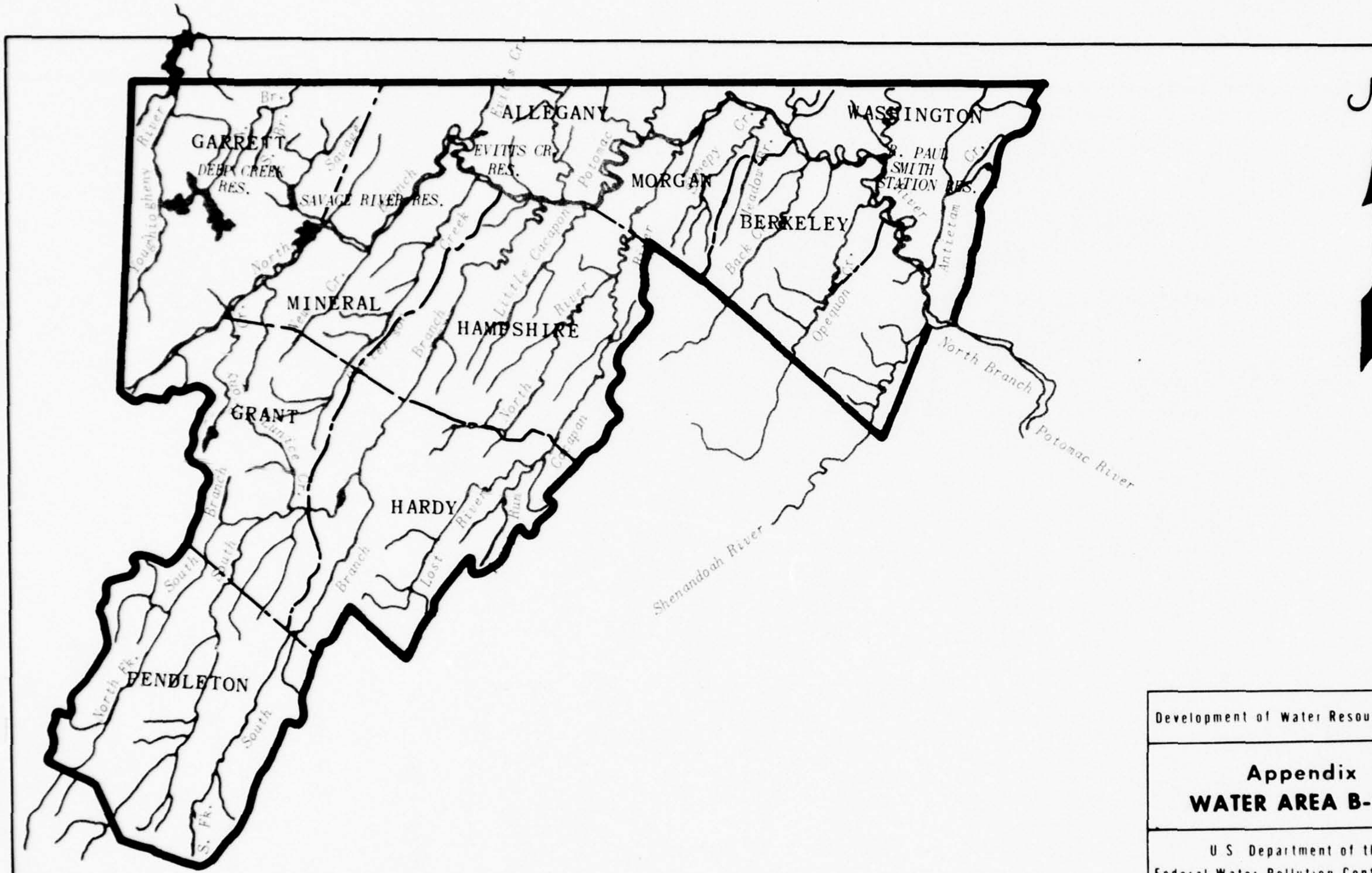
Table B-3

Water Supply Needs in Million Gallons per Day for
Municipal and Industrial Use
to meet Benchmark Goals

1960	1980	2000	2020
132	180	300	510

Untreated Waste Loadings (P.E. in 1,000's)
Accruing from Benchmark Goals

1960	1980	2000	2020
641	717	1130	1900



Development of Water Resources in Appalachia

Appendix D
WATER AREA B-3 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA C RESUME

WATER SUPPLY REQUIREMENTS

Present

In water area C, water use by municipalities and industries is centered predominantly in the Clifton Forge-Covington area. Process water for the production of pulp and paper products constitutes the major use of water in the area. Water supply is obtained mainly from surface water sources, primarily the Jackson River. Present municipal and industrial water uses are shown in Table C.

Future

Existing and proposed development of ground and surface water resources of the area appear to be adequate to meet projected future water supply requirements.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality in the major streams is generally suitable to satisfy most beneficial uses. Because of industrial waste discharges, localized degradation of water quality occurs in the Jackson River below the Clifton Forge-Covington area. Present municipal and industrial waste loadings are shown in Table C.

Water Pollution Control Program

The Gathright Reservoir, which is under construction in the headwaters of the James River, will provide flow regulation for water quality control in the Clifton Forge-Covington area. When completed, flow from this reservoir should satisfy water quality demands through the year 2020.

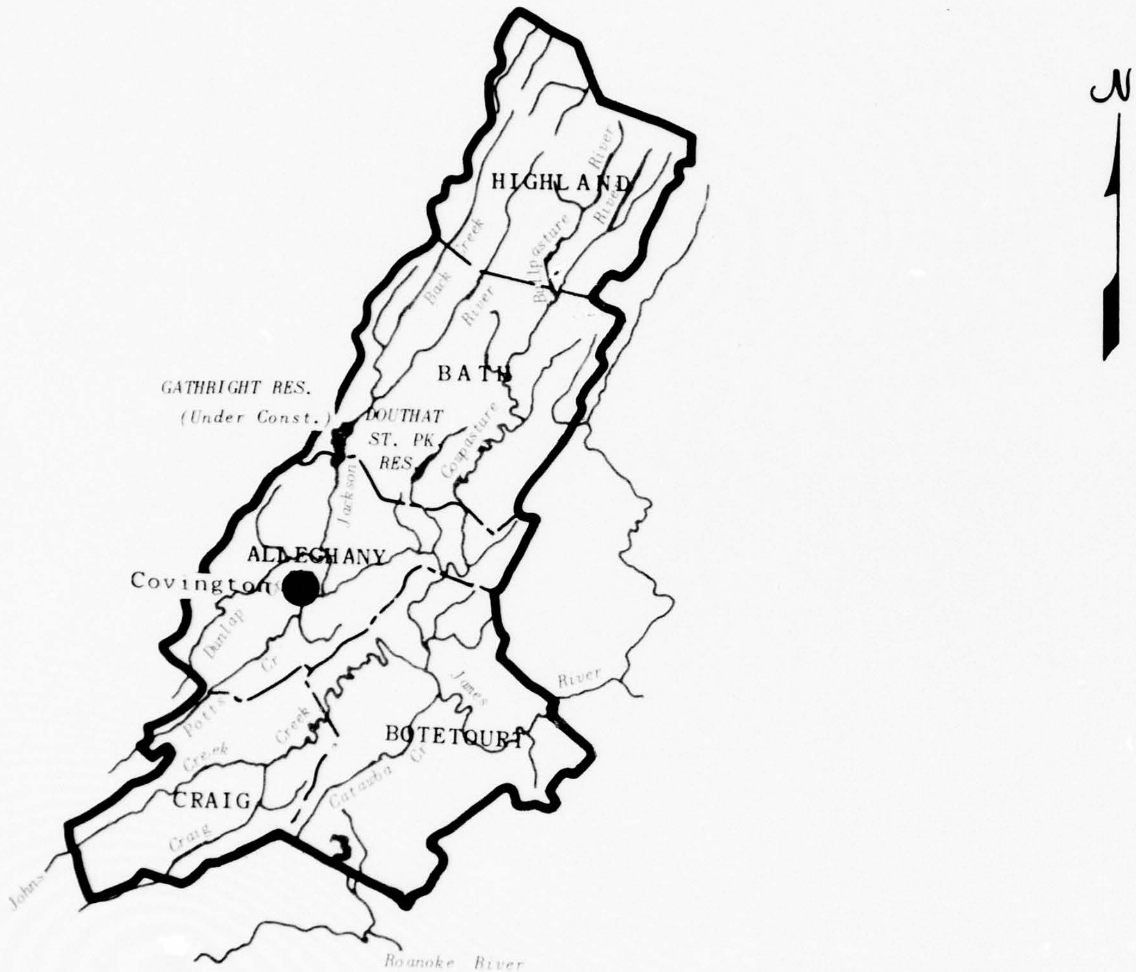
Table C

Water Supply Needs in Million Gallons per Day for
Municipal and Industrial Use
to meet Benchmark Goals

1960	1980	2000	2020
47	56	76	95

Untreated Waste Loadings (P.E. in 1,000's)
Accruing from Benchmark Goals

1960	1980	2000	2020
296	330	450	540



Development of Water Resources in Appalachia

Appendix D
WATER AREA C MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

WATER AREA D-1 RESUME

WATER SUPPLY REQUIREMENTS

Present

The major water supply stream in this area is the Yadkin River, which serves as the principal source for the Winston-Salem SMSA. The W. Kerr Scott Reservoir on the Yadkin River is the major water supply impoundment.

The water use by the industries and municipalities is generally widespread among the many communities within water area D-1. The one exception is the Winston-Salem SMSA, which uses approximately four to five times the amount of water used elsewhere in the water area. Municipal and industrial water uses are presented in Table D-1.

Future

Based on river basin studies by the Middle Atlantic Region in water area D-1 there are indications that the present streamflows, ground water supplies, and existing reservoirs will be sufficient to satisfy the water needs of the area, which includes the Winston-Salem SMSA through the year 2020.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality of the streams in the area is generally of such quality that the beneficial uses of the water are not impaired. An exception is Muddy Creek and its tributary Salem Creek, the immediate receiving stream which has a definite water quality problem in terms of dissolved oxygen associated with the BOD loading from the Winston-Salem SMSA. Present municipal and industrial raw waste loadings are presented in Table D-1.

Water Pollution Control Program

River basin studies by the Middle Atlantic Region indicate that the base flow of the streams, plus planned reservoirs in the Yadkin River Basin will be sufficient to maintain water quality objectives, except in Muddy Creek. Engineering studies are under way by the city of Winston-Salem and its consulting engineers. The Federal Water Pollution Control Administration is assisting the

North Carolina Board of Water and Air Resources in determining the waste assimilative capacity of Salem and Muddy Creeks by mathematical model basin study techniques, and corrective measures are due to be constructed and placed in operation on or before July 1, 1970. The proposed Clinchfield Reservoir located in this water area is being considered for water quality storage; however, it would provide benefits to water quality primarily in water area D-2.

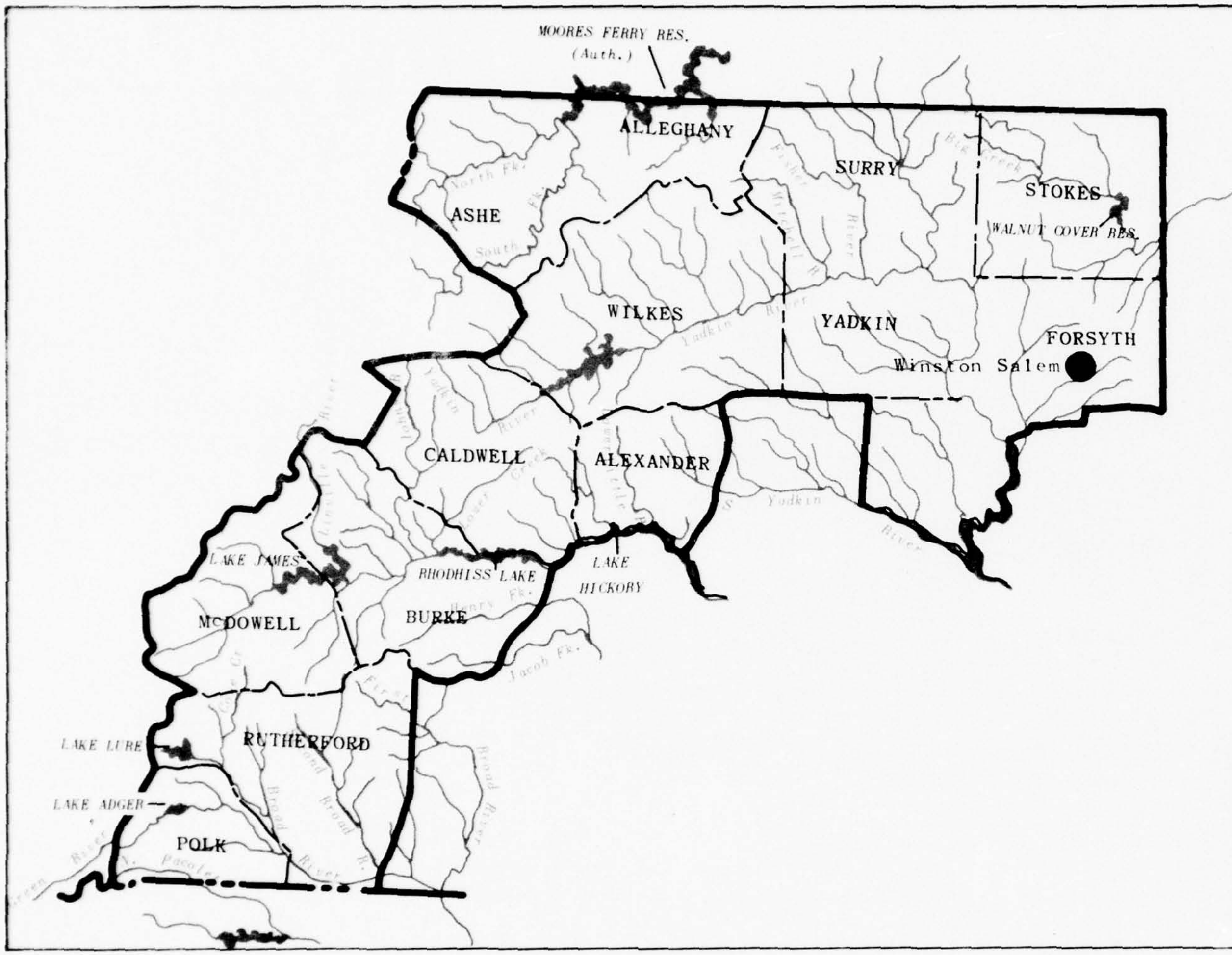
Table D-1

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
55	160	370	750

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
689	1900	4300	8200



Development of Water Resources in Appalachia

Appendix D
WATER AREA D-1 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA D-2 RESUME

WATER SUPPLY REQUIREMENTS

Present

The water use by the industries and municipalities in water area D-2 is predominantly located in Greenville and Spartanburg Counties. The largest water user in the water area is the Greenville SMSA. In the other counties the water use is generally widespread. The Duke-Toxaway Reservoir which is now under construction, and for purposes of this report is considered as being in place, along with the North Saluda Reservoir and Table Rock Reservoir are the sources of supply for Greenville, The principal source of water supply for Spartanburg, is Lake Wm. C. Bowen. Table D-2 presents the municipal and industrial water use.

Future

River basin studies by the Middle Atlantic Region indicate that Spartanburg County will need a water supply which can be obtained from the Clinchfield Reservoir. Other studies indicate that the base flow of the streams plus the existing reservoirs will be capable of satisfying the water requirements of the Greenville SMSA through the year 1985. Should areas not easily supplied by existing water sources develop because of economic factors other than water supply, additional water supply development would be needed.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality of the streams in area D-2 is generally of such quality that the beneficial uses are not impaired except in portions of the Tyger, Reedy, Enoree, and Pacolet Rivers where dissolved oxygen levels sometimes drop below the State stream standards during critical seasons of low streamflow. Raw waste loadings for municipalities and industries are presented in Table D-2.

Water Pollution Control Program

River basin studies by the Middle Atlantic Region in water area D-2 indicate that the base flow in the Broad River plus the planned Clinchfield Reservoir, located in water area D-1, would be capable of maintaining water quality objectives in the Broad River. Studies of the other major streams should be made to determine the need for flow augmentation, higher degrees of treatment, and in-plant controls.

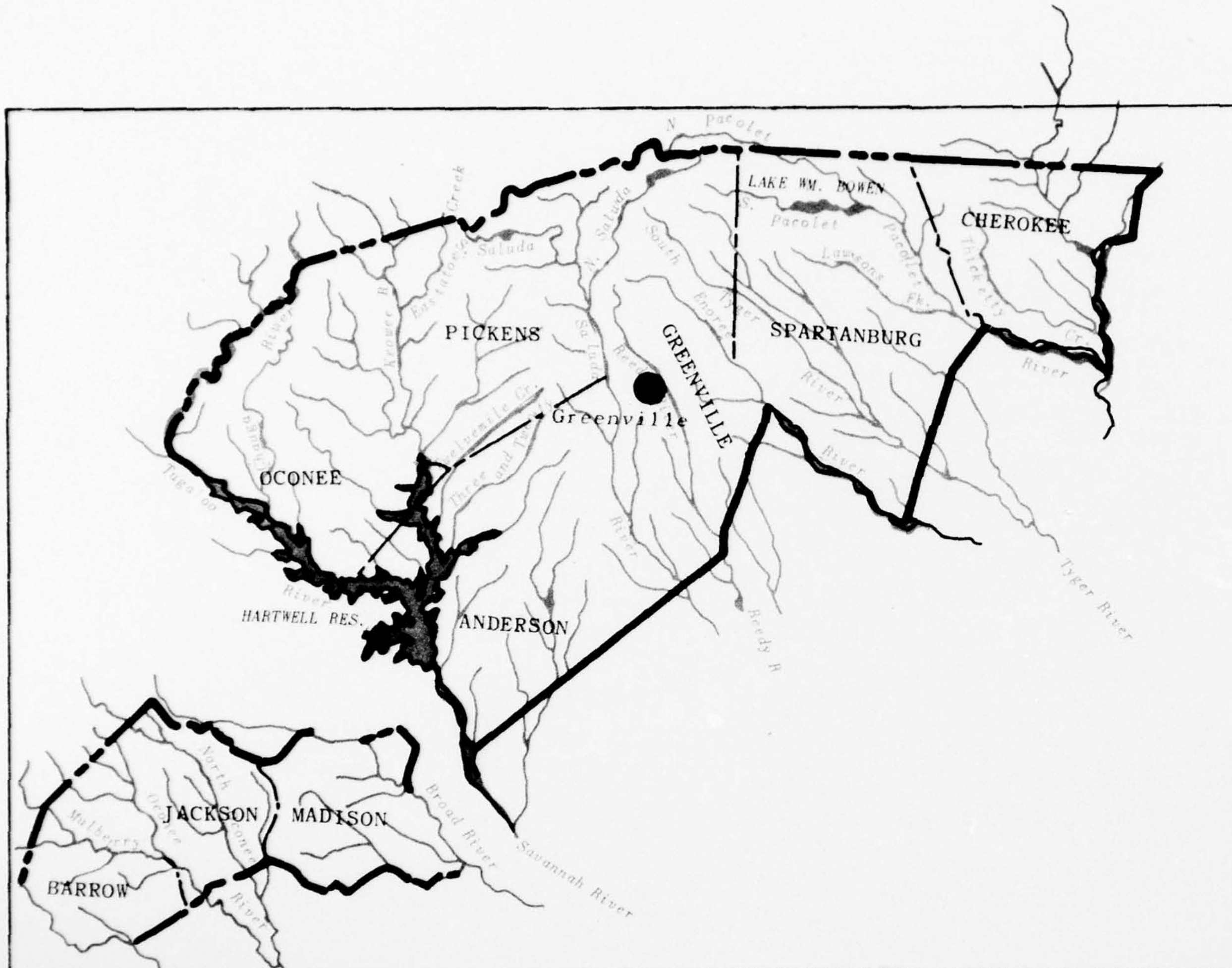
Table D-2

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to Meet Benchmark Goals

1960	1980	2000	2020
103	200	375	660

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
3493	3670	4800	8450



Development of Water Resources in Appalachia

Appendix D
WATER AREA D-2 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA E-1 RESUME

WATER SUPPLY REQUIREMENTS

Present

The northern half of this water area lies in the Blue Ridge Province, where ground water is not plentiful. Nevertheless, owing to abundant and regular precipitation, many "well-sustained" springs provide the water supply to numerous towns and rural areas. Presently, no large industries use ground water in this area.

The southern portion lies in the Piedmont Province, which has one of the Nation's most reliable aquifers for the small yields needed for domestic supplies. Although surface water is abundant in this area, springs and/or wells supply approximately 19 percent of the water used by municipal water facilities.

Future

The water supply needs indicated by the benchmark goals of development can be met through proper development and management of present resources.

WATER POLLUTION CONTROL

Water Quality Problems

The major pollution problems affecting water users of this area arise from a combination of untreated or inefficiently treated municipal and industrial wastes discharged into the streams.

Lake Lanier, at the embayment area of Balus Creek, exhibits high BOD's and high total coliform due to poultry processing waste in an overloaded secondary treatment plant. The city of Toccoa and a large textile mill discharge their untreated waste into several creeks in the upper reaches of Lake Hartwell. Pollution in Eastanolle Creek is critical. The discharge of untreated waste from the city of Ellijay is detrimental to the waters of the Coosawattee River.

Water Pollution Control Program

All industries and communities presently discharging inadequately treated wastes will be required to meet the treatment requirements and abatement schedules established by the Georgia Water Quality Control Board. The basic requirement, which will be enforced in accordance with the State's law, is secondary (biological) treatment with disinfection where necessary for domestic sewage and equivalent treatment for industrial waste.

Engineering studies have been completed by the city of Toccoa to solve its domestic and industrial pollution problems. An engineering report has also been completed which outlines the needs to abate the pollution contributed by the wastes which the city of Ellijay discharges into the water course of the Coosawattee River. Based on this report, the city of Ellijay is going to build a secondary sewage treatment plant. Its estimated cost is $932,600. The total grant is $528,000 of which $91,047 is from FWPCA and $437,233 is from Appalachia Regional Commission. Plans and specifications should be completed by September 1968.

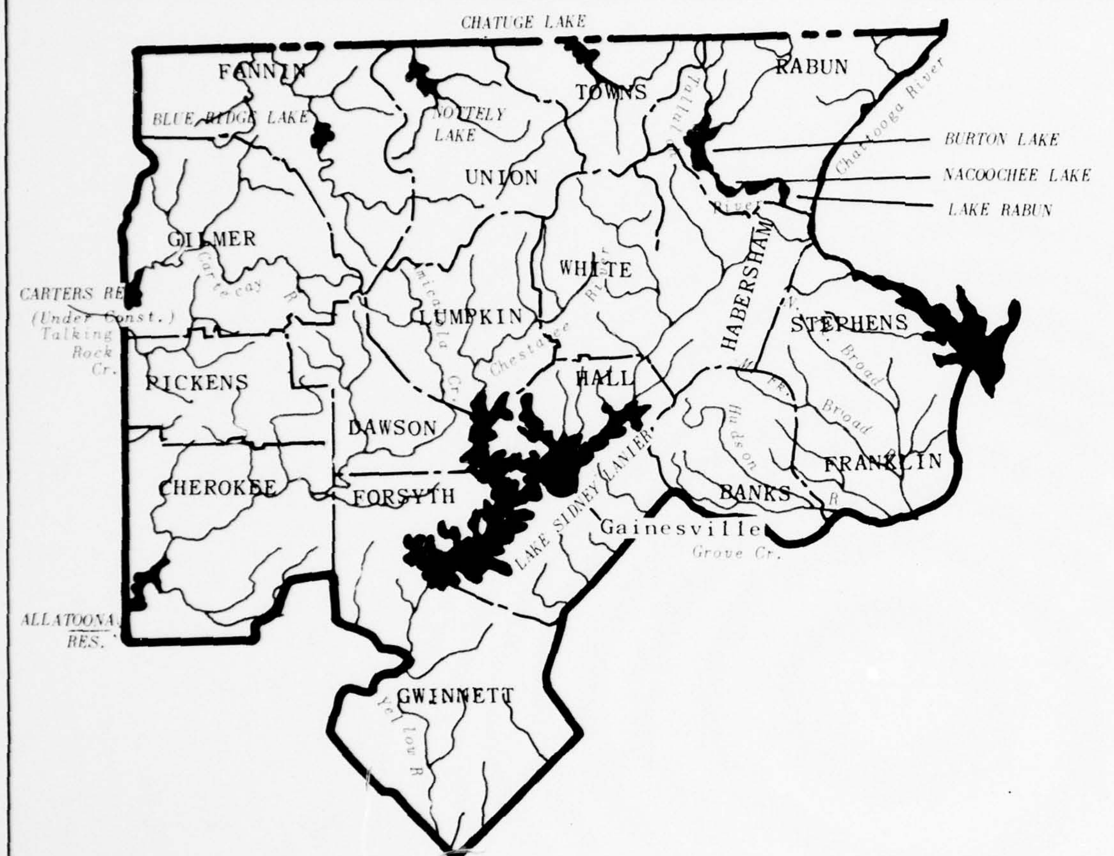
Table E-1

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
25	67	140	240

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
280	650	1280	2200



Development of Water Resources in Appalachia

Appendix D

WATER AREA E-1 MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

WATER AREA E-2 RESUME

WATER SUPPLY REQUIREMENTS

Present

The northern two-thirds of this water area lies in the Valley and Ridge Province where large ground water supplies are abundant. Approximately 25 percent of the municipal water supply comes from springs and/or wells, although surface water is also abundant. Nevertheless, during drought, water shortages are commonly severe. Impoundments are then necessary to provide flow augmentation. Present water use is largely centered in the areas of Dalton, Summerville, Rome, and Cartersville.

Future

The significant increase in water supply needs indicated by the benchmark goals of development can be met through construction of impoundments and proper management of present water resources. This will be a critical necessity during drought periods.

WATER POLLUTION CONTROL

Water Quality Problems

The water quality in this area, as well as in all of the Georgia Appalachia area, can be defined as localized rather than covering an entire river basin.

On the Chattooga River, the most serious of the pollution problems is centered around the cities of Trion and Summerville. Untreated wastes from both cities, coupled with that from a large textile mill, has degraded the water quality to such an extent that any further use is prohibited. Similar problems on the Etowah River are caused by waste from the city of Cartersville; on the Big Cedar Creek, by waste from the city of Cedartown; on the Tallapoosa and Chattahoochee Rivers, by waste from the city of Villa Rica; on the Conasauga River, by either untreated or partially treated waste from the city of Chatsworth and local industry; on the Oostanaula River, by untreated wastes from the city of Calhoun and several textile mills; and on the Coosa River, by wastes from the city of Rome and numerous large and small industries.

Water Pollution Control Program

The significant growth indicated by benchmark goals will require strict implementation and enforcement of the treatment requirements established by the Georgia Water Quality Control Board. All domestic sewage will be given a minimum of secondary (biological) treatment, with disinfection where necessary; equivalent treatment of all industrial wastes will be required.

The city of Cartersville has received a grant of $545,400 for the construction of a primary treatment facility. Upon completion of this phase, the city will provide facilities for secondary treatment. All other cities in this area now polluting the stream at least have completed engineering studies in order to solve their problems. A total of $3,235,000 in grants, of which $2,284,400 is from FWPCA and $950,600 from Appalachia Regional Commission, has been awarded to the cities of Trion, Summerville, Calhoun, Villa Rica, Chatsworth, and Rome for construction of secondary treatment facilities. Several industries either have begun or are now planning the necessary facilities to solve their pollution problems.

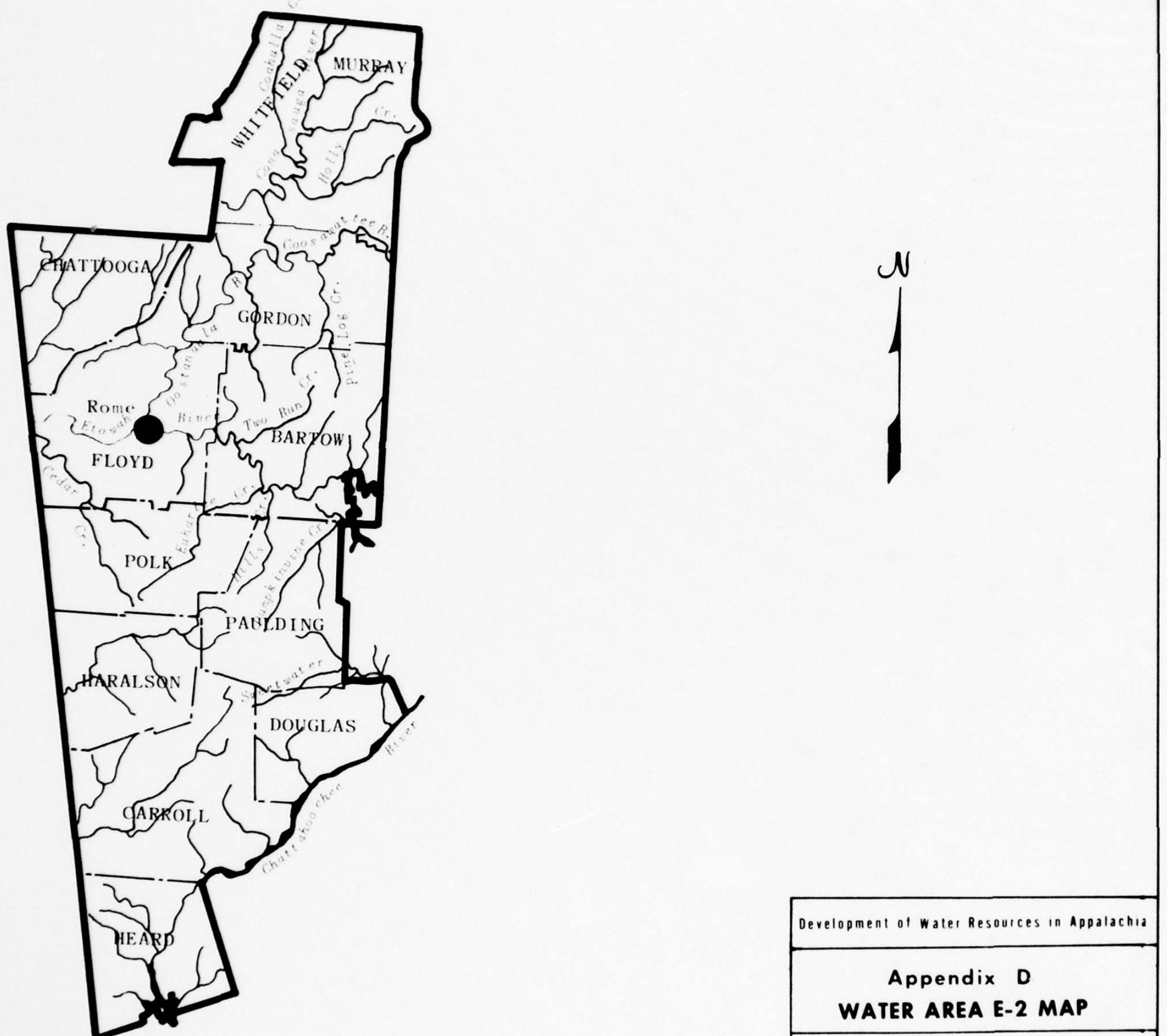
Table E-2

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
66	170	350	680

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
590	1170	2330	4300



Development of Water Resources in Appalachia

Appendix D
WATER AREA E-2 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA E-3 RESUME

WATER SUPPLY REQUIREMENTS

Present

Approximately half of this water area lies in Piedmont Province where there are numerous small yields of ground water needed for domestic supplies of thousands of rural and suburban homes. The remainder is divided among the Coastal Plain Province and Valley and Ridge Province and the Appalachian Plateaus. Approximately 45 percent of the water being supplied by municipal facilities in this water area comes from wells and springs. Surface water is also abundant throughout the area.

Future

The water supply needs derived from benchmark goals can be met by the existing supplies of ground and surface water; however, construction of some impoundments will be necessary to fulfill these foreseeable water needs. The towns of Wadley, Dadeville, Heflin, and Roanoke are likely to need water from such impoundments.

WATER POLLUTION CONTROL

Water Quality Problems

Most of the surface water is provided by the Coosa and Tallapoosa River Basins. The remainder comes from the Chattahoochee River Basin. In general, the quality of water in the Coosa and Tallapoosa River Basins is good. This is particularly true of the main streams of the Coosa and Tallapoosa Rivers and of their impoundments. However, there have been instances of fish kills caused by release of untreated or improperly treated industrial wastes. Also, there are still a few municipalities within the area that discharge untreated or improperly treated domestic wastes into the Coosa and Tallapoosa Rivers. The Chattahoochee River, which supplies water for domestic and industrial uses in the cities of Lanett, Fairfax and Langdale, has its water quality degraded by industrial and municipal wastes.

Water Pollution Control Program

The Alabama Water Improvement Commission requires secondary treatment of all municipal wastes. Therefore, all the municipal facilities contributing to pollution are expected to have secondary treatment, or its equivalent, in the near future. Plans for abatement or control of pollution resulting from the discharge of untreated or inadequately treated industrial wastes to the waters of the Coosa and Tallapoosa River Basins have to be submitted by the offenders.

Table E-3

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
107	230	400	670

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
510	1080	1940	3300

Development of Water Resources in Appalachia

Appendix D
WATER AREA E-3 MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

WATER AREA E-4 RESUME

WATER SUPPLY REQUIREMENTS

Present

Approximately 8 percent of the water being supplied by municipal facilities comes from springs and/or wells. Impoundment or surface water is necessary throughout the area in order to provide the water needs during the dry summer months. Water use is largely concentrated in the Birmingham area and, to a lesser extent, in Tuscaloosa.

Future

The water supply needs indicated by the benchmark goals can be met by present base flow, plus possible reallocation of storage in impoundments.

WATER POLLUTION CONTROL

Water Quality Problems

The major pollution problems affecting the water quality in this area arise from a combination of untreated or inefficiently treated municipal and industrial wastes discharged into streams with insufficient assimilating capacities under normal existing flow conditions. Jefferson County is the most heavily polluted area in the State. In 1966, 75 percent of the fish reported killed in Alabama, and 10 percent of the fish reported killed in the entire Nation, were in Jefferson County. However, with the exception of highly polluted stream reaches in the Birmingham and Tuscaloosa areas, the water quality problems in this area are localized in extent.

Water Pollution Control Program

Most of the streams in the Birmingham metropolitan area have a proposed water quality classification of untreated waste transportation because of the heavily polluted conditions. Secondary treatment of biodegradable organic wastes will help solve much of the present pollution problem. The Alabama Water Improvement Commission requires secondary treatment of all municipal wastes. Therefore, most of the facilities now contributing to pollution will have secondary treatment, or its equivalent, in the near future. The benchmark goals

indicate a need to consider flow control and/or advanced waste treatment to protect the quality of waters in the future. Most of those responsible for the discharge of industrial wastes into the streams of this area have been directed to submit plans for pollution abatement.

Table E-4

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
390	710	1370	2250

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
1450	2900	6000	9800

Development of Water Resources in Appalachia

Appendix D
WATER AREA E-4 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA E-5 RESUME

WATER SUPPLY REQUIREMENTS

Present

This water area lies along the eastern flank of the Mississippi embayment of the East Gulf Coastal Plain Province. The entire area is underlain with water producing aquifers. Approximately 75 percent of the water being supplied by municipal facilities comes from springs and/or wells. Of the many water facilities existent in the area, only Columbus obtains its water from a surface supply, the Luxapallila Creek.

Future

Economic studies of the Office of Business Economics and the benchmark development goals show a very large growth in the paper and chemical industries which will result in a considerable increase of the present water use. The vast ground water resources and the efficient use of the substantial flows in several of the streams in the region, coupled with the construction of dams to take advantage of the 51 inches average annual precipitation, will adequately take care of this greatly expanded water use.

WATER POLLUTION CONTROL

Water Quality Problems

At the present time, water pollution is not considered a major problem in this area. However, there are water quality problems which are rather localized in extent. The main source of pollution causing these localized problems is a combination of untreated or inefficiently treated municipal and industrial wastes. As a result of these wastes, several fish kills have occurred in these problem areas. Low dissolved oxygen values have been observed in Town Creek, a tributary of Tibbee Creek, south of West Point, and in the Noxubee River near Macon. Several fish kills have been reported in the Luxapallila Creek near Columbus. However, a large oxidation lagoon has been constructed recently. It is not known, at this time, to what extent this lagoon has been utilized by the industry.

In this 20-county area of Mississippi, 115,000 people in twenty-seven communities are presently connected to sewerage systems discharging approximately 11.5 million gallons per day. The wastes from all but

6,200 people in five communities are currently receiving adequate secondary treatment or will be in the near future. In addition, a number of small communities (population less than 500) are without sewer systems and, therefore, without treatment plants. The basin's approximately 80 industries are predominantly textiles. Little information is currently available concerning industrial wastes and treatment, although it is known that several industries do not treat their wastes.

Water Pollution Control Program

The benchmark goals of development indicate a need to consider flow control and/or advanced waste treatment to protect waters in the future.

The proposed Mississippi Water Quality Standards require a minimum of secondary or equivalent treatment of all wastes not later than 1972. The Mississippi Air and Water Pollution Control Commission, which has the authority to control, prevent, or abate the pollution of waters in the State, plans to accomplish within the next ten years the following: (1) control of any pollution caused by combined sewer overflows, (2) reduction of nutrients contributed by treated sewage effluents, and (3) use of tertiary treatment where needed.

Table E-5

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
25	120	510	1000

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
110	680	2300	4200

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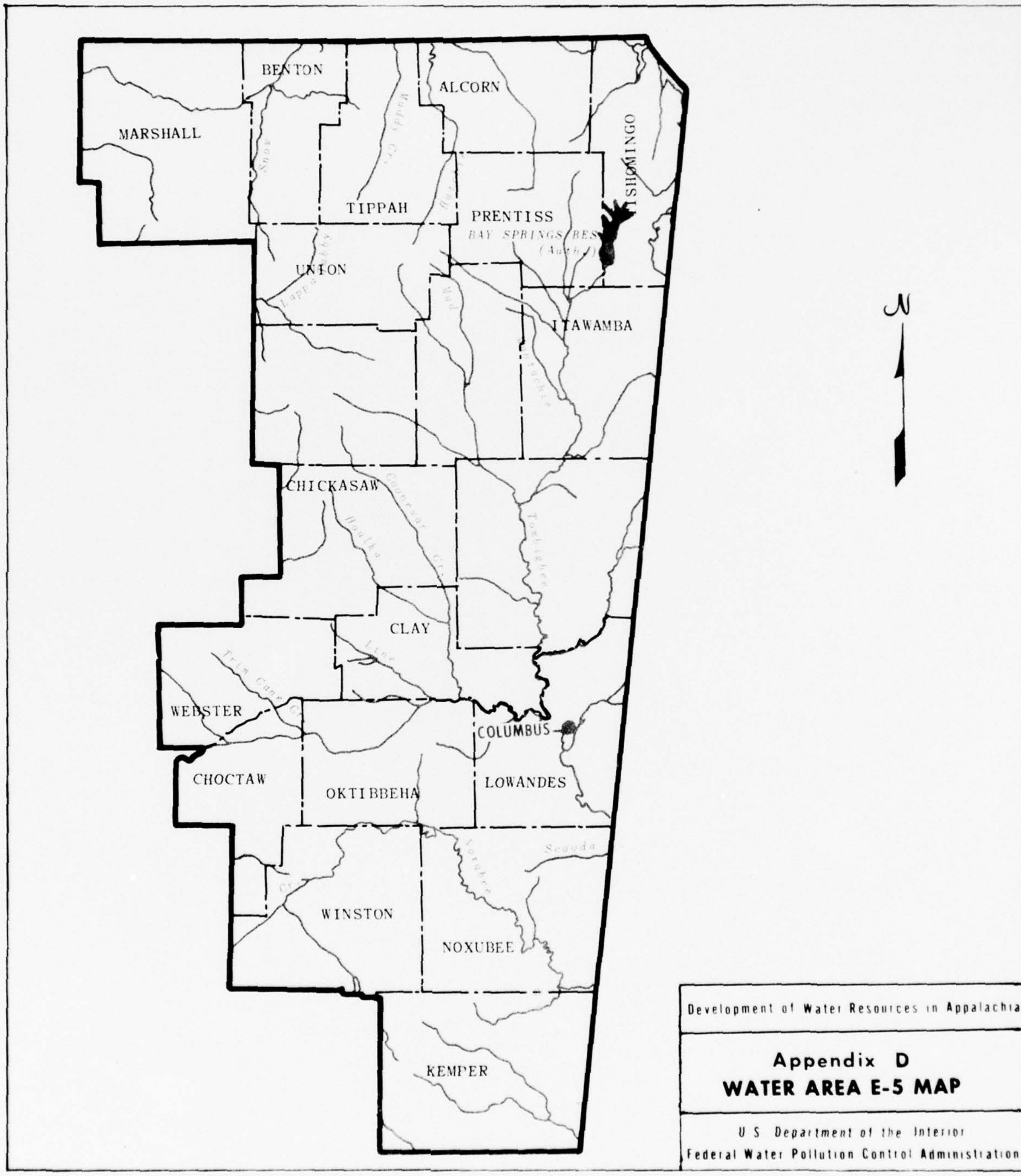


Development of Water Resources in Appalachia

Appendix D
WATER AREA E-5 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA F-1 RESUME

WATER SUPPLY REQUIREMENTS

Present

In water area F-1 the major water use is for the Erie SMSA, with Lake Erie its source of supply. This accounts for about 20 percent of the area's total municipal and industrial water use. The remaining water supply use is widely dispersed between the many small- and moderate-sized communities in the area. Ground water is the major source of municipal water supply in the New York counties and in those Pennsylvania counties exclusive of the southeast and southwest portions of the water area.

Future

The water supply needs derived from benchmark goals indicate sufficient water supply is available for those portions of the area along Lake Erie; also, sufficient water supply is available from river base flow and from outwash and alluvial fill ground water sources in the northwest and north central areas. Existing or planned lakes and reservoirs (Lake Chautauqua, Allegheny, Tionesta, Mahoning Creek, Shenango and Pymatuning Reservoir areas) provide a further water resource available with possible reallocation of storage. This area can be concluded to have a very ample supply of existing and developable water supply, providing water quality control programs are suitably implemented.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality is degraded by oil field brine wastes in the northern Pennsylvania counties. Water quality is degraded by pulp and paper wastes from Erie, Pennsylvania. Lake Erie is degraded by nutrients from municipal, industrial, and agricultural sources, and to a lesser extent by bacteria from municipal sources. During periods of sewage bypass and lack of disinfection at sewage treatment plants, a few bathing beaches along the lake are affected. Acid mine drainage has degraded the Clarion River and Redbank Creek as well as some small streams (see Appendix C).

Water Pollution Control Program

The chloride pollution problems from oil brines should be subjected to control by locating and capping abandoned wells and by close control over operating wells.

Recommendations from the Lake Erie Enforcement Conference should be followed to protect these waters. Secondary treatment with nutrient control plus disinfection of all sewage effluents to protect bathing beaches are presently judged to be important needs. Secondary treatment of pulp and paper wastes at Erie, Pennsylvania, is an important industrial need.

The pollution control program as it relates to mine drainage control is discussed in Appendix C.

Water quality along the main stem of the Allegheny should benefit from releases, from Allegheny River Reservoir, largely keyed to needs on the Allegheny River at Natroma.

For upstream reaches, for small streams receiving organic wastes, and for French Creek below Meadville, high levels of treatment, in-plant control, and opportunities for flow regulation need to be given high priority should substantial development occur.

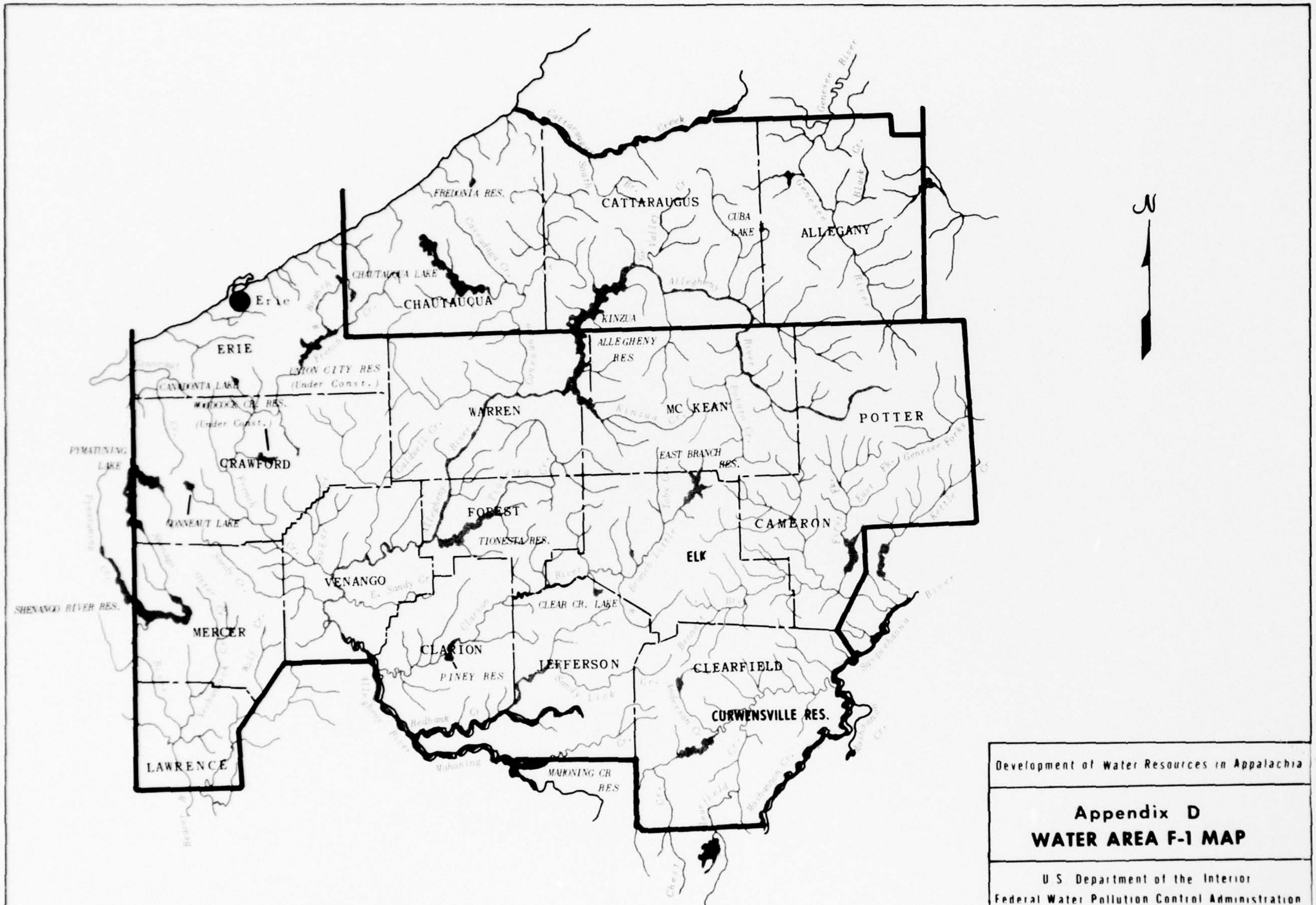
Table F-1

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
500	820	1400	2000

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
1650	2600	4700	6700



Development of Water Resources in Appalachia

Appendix D
WATER AREA F-1 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA F-2 RESUME

WATER SUPPLY REQUIREMENTS

Present

The water area F-2 present water use is largely concentrated in the three-county Pittsburgh SMSA (see Table F-2). Water supply is predominately from the surface sources of the Ohio, Monongahela, Allegheny, and Youghiogheny Rivers. The alluvium along the Ohio River, lower Allegheny River, and the lower Monongahela River is a lesser but still significant source of supply.

Future

The water supply needs derived from the benchmark goals indicate ample supply from presently developed surface water sources to meet future needs. Ground water from alluvial sources is expected to continue to provide a lesser but important source of supply.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality in the water area is severely degraded by acid mine drainage. In the Monongahela River Basin, the lower Monongahela River is continuously acid. Tributaries to the lower Monongahela that are significantly degraded by coal mine drainage include the Youghiogheny River, Cheat River, Dunkard Creek, Ten Mile Creek, and Redstone Creek. Significantly degraded tributaries to the lower Youghiogheny River include the Casselman River and Sewickley Creek.

In the Allegheny River Basin, Crooked Creek, and Kiskiminetas River and its tributaries, the Conemaugh and Little Conemaugh Rivers and Blacklick, Loyalhanna, and Blacklegs Creeks are significantly and continuously degraded. The Allegheny River itself is frequently acid below the mouth of the Kiskiminetas River.

In the Beaver River Basin, Slippery Rock Creek and many of its tributaries are degraded by acid mine drainage (for more detail see Appendix C).

The Beaver River is affected by organic and industrial wastes largely from the Mahoning River Basin. A pollution abatement program now under way should serve to improve Beaver River quality.

The Ohio River below Pittsburgh is degraded by organic wastes, oil pollution from industrial sources, and the effect of mine drainage from the Mongahela and Allegheny Rivers can be detected.

Water Pollution Control Program

Because of the great quantities of acid mine drainage and municipal and industrial wastes in this area, pollution control expenditures can be expected to exceed those of any other Appalachia water area. Mine drainage pollution control measures are detailed in Appendix C.

Water quality improvement in the Ohio River can be expected to result from secondary treatment facilities now in the planning stage for the Allegheny County Sanitary Authority serving most of the sewered population in the Pittsburgh area. Biodegradable organic wastes from other municipal sources as well as from industry are scheduled to receive secondary treatment by 1972 along the main stem of the Ohio River. Regulated flow from upstream reservoirs will serve to further improve water quality by increasing the 30-consecutive-day low flow with a 10-year recurrence frequency from a natural level of 2,400 cfs to 5,600 cfs. This is expected to satisfy water quality needs until about 1980. After 1980 in-plant control, advanced waste treatment, additional flow augmentation and other control measures are expected to be required to maintain water quality.

Control measures including in-plant control, advanced waste treatment, and flow regulation or other measures will also be necessary in headwater areas where significant development exists or will take place.

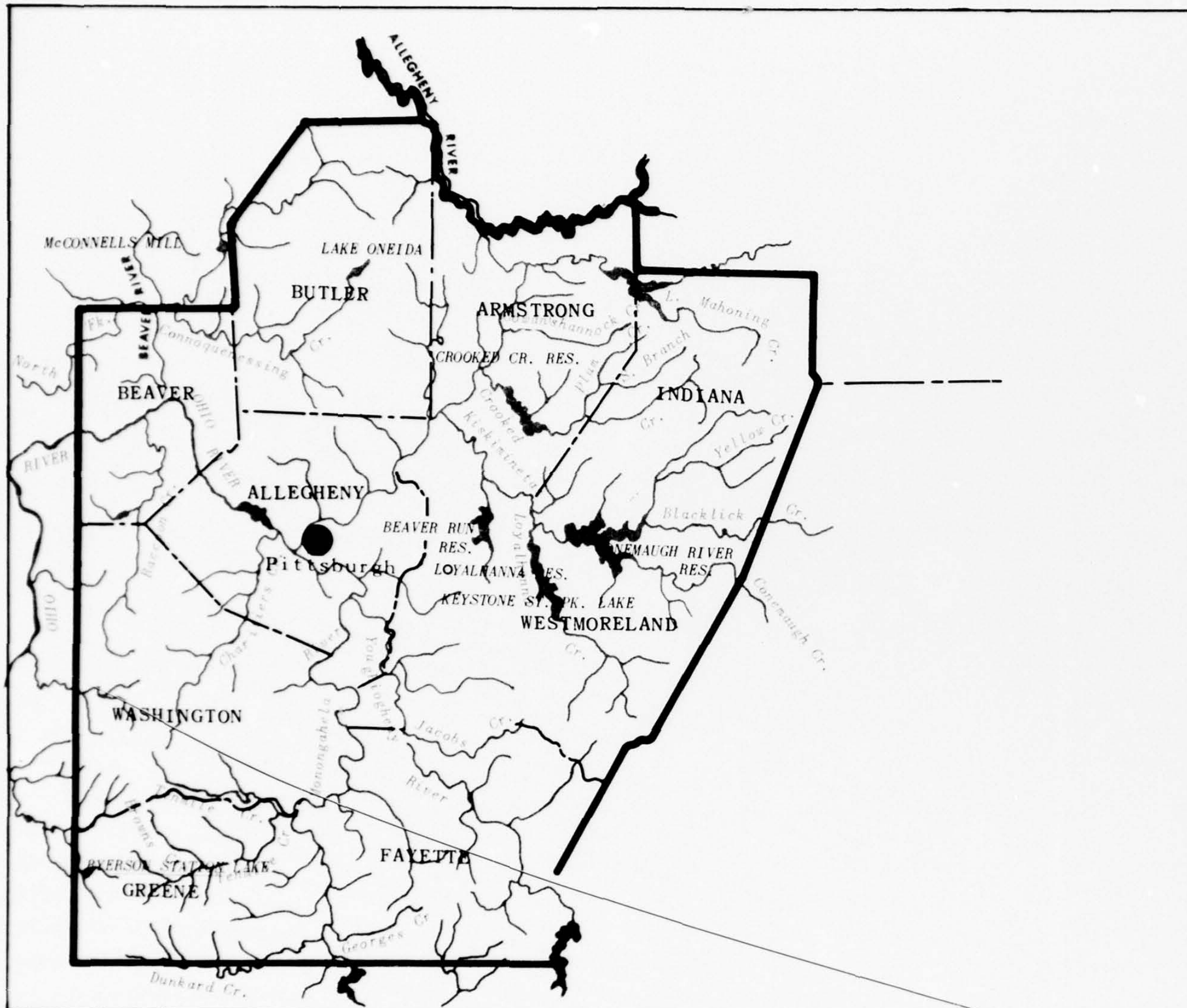
Table F-2

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to Meet Benchmark Goals

1960	1980	2000	2020
2550	3200	4050	6050

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
4260	5700	8800	16,100



Development of Water Resources in Appalachia

Appendix D

WATER AREA F-2 MAP

U S Department of the Interior

Federal Water Pollution Control Administration

WATER AREA F-3 RESUME

WATER SUPPLY REQUIREMENTS

Present

Present water use in water area F-3 is largely concentrated in the Weirton and Wheeling SMSA (see Table F-3). Most of the remaining water use is in the Morgantown, Fairmount, and Clarksburg, West Virginia, areas.

Water supply is mostly from the Ohio River. However, the Monongahela River, West Fork River, Tygart Valley River, and Cheat River, along with ground water from the alluvium along the Ohio River, are important lesser sources of supply.

Future

The water supply needs derived from the benchmark goals indicate the Ohio River and associated alluvium are ample to supply the needs of the immediately adjacent counties. Clarksburg, West Virginia, and upstream areas which might have significant development will require additional water resource development to supply needs. Impoundment would be the most likely source of providing additional water supply needs in these areas.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality in the Ohio River is degraded by high bacterial levels and sporadic oil pollution from industrial sources.

The Monongahela River is heavily degraded by mine drainage. The West Fork Tygart Valley and Cheat Rivers are also highly affected by mine drainage. For more detail on mine drainage problems see Appendix C.

Water Pollution Control Program

Control of pollution from biodegradable organics and bacterial pollution in the Ohio River will require secondary treatment and disinfection of wastes. Discharge of nutrients can be expected to be an increasing problem and may require additional treatment measures when and if problems develop. Present and future research can be expected to provide suitable measures for control of nutrients from controllable discharges.

An extensive mine drainage abatement program will be required in the Monongahela Basin portion of the water area. The pollution control program as it relates to mine drainage is discussed in Appendix C.

Additional treatment of biodegradable organic wastes will be required in the Monongahela Basin in addition to control of mine drainage pollution.

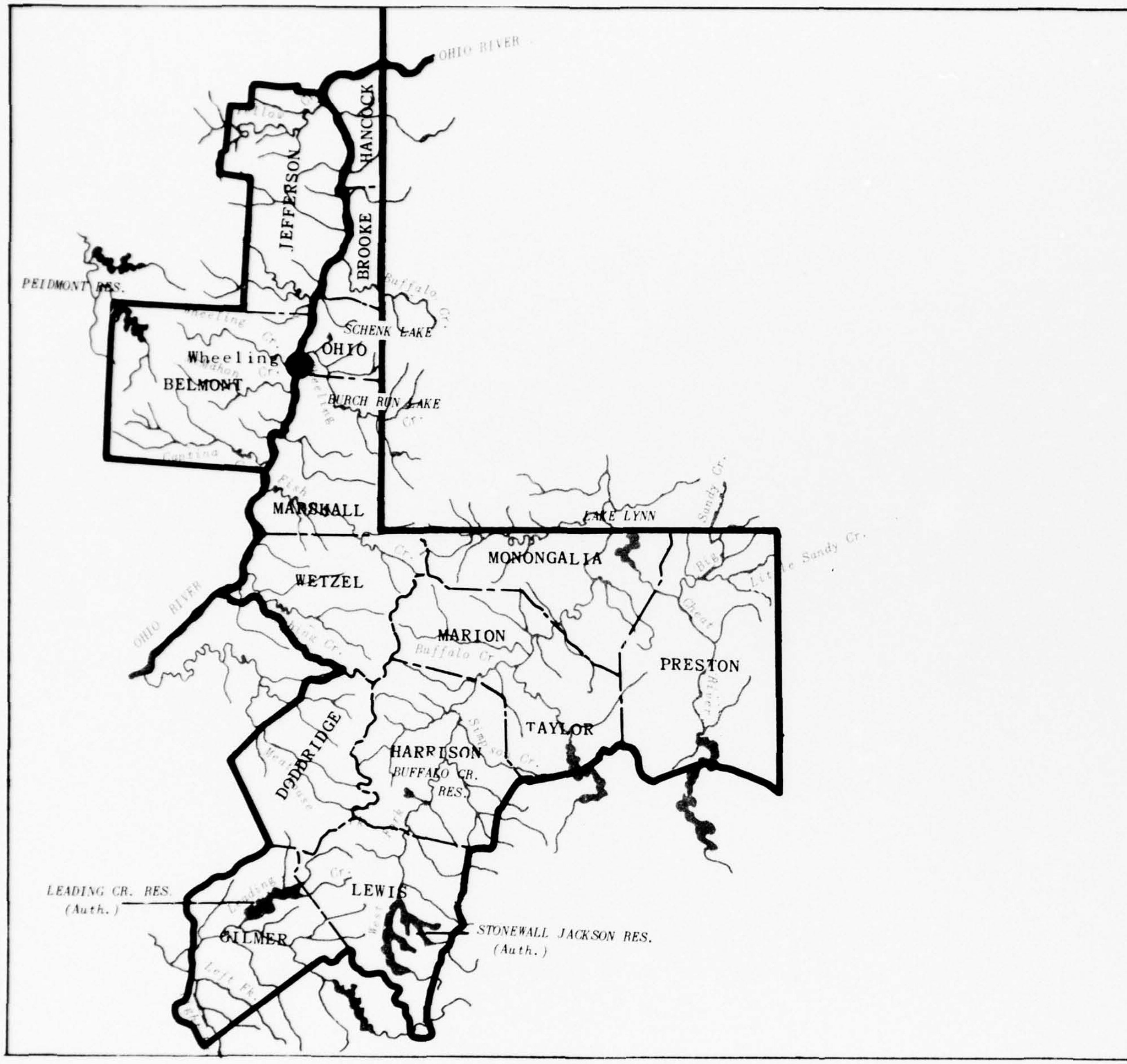
Table F-3

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
380	550	930	1600

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
760	1100	2000	4300



Development of Water Resources in Appalachia

Appendix D
WATER AREA F-3 MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

WATER AREA G-1 RESUME

WATER SUPPLY REQUIREMENTS

Present

Present water supply requirements are provided mostly from ground water sources. Use is well dispersed among the numerous small- and moderate-sized communities.

Future

Water supply needs to meet benchmark goals can generally be met from expansion of present ground water sources and increased use of surface supplies in the Ohio and lower Muskingum Rivers. Should significant development occur in upstream areas, development of new ground water or surface water sources is indicated.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality in the Ohio River is adequate to protect legitimate uses as measured by most parameters. Oil pollution is an intermittent problem as it is in reaches above and below the G-1 water area. Fish flesh tainting is an additional chronic problem in the Ohio River.

Water quality in the Muskingum River and its tributary, the Tuscarawas River, is affected by brine discharges in the upper Tuscarawas River.

A number of small streams in the eastern counties of the water area are affected by acid mine drainage. For more detail see Appendix C.

Water Pollution Control Program

Water quality in the two major streams, the Ohio and Muskingum Rivers, will largely be determined by water quality control measures taken in upstream areas. Solution of the brine pollution problem in the Muskingum basin would provide a significant additional resource of water for public and municipal water supply, as well as improve aquatic life resources.

Secondary treatment and chlorination of wastes along the Muskingum and Ohio Rivers should adequately protect uses if the waters entering the water area are of good quality. Should significant development occur along the small streams and in headwater areas, measures of in-plant control, advanced waste treatment, selective discharge of effluents, and flow regulation will have to be considered.

For a further discussion of solutions to mine drainage problems see Appendix C.

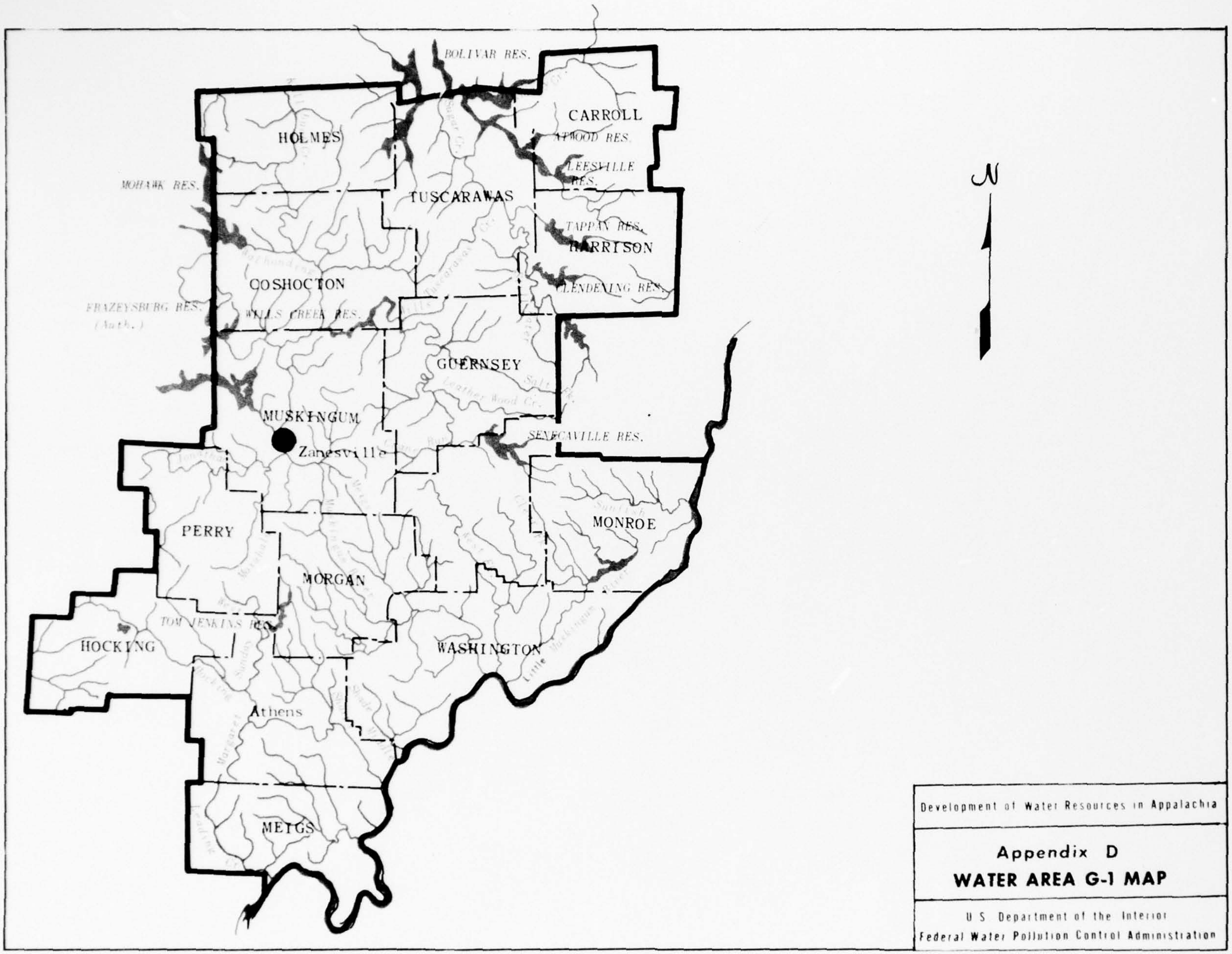
Table G-1

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
80	200	420	710

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
490	810	1400	2250



Development of Water Resources in Appalachia
Appendix D **WATER AREA G-1 MAP**
U S Department of the Interior Federal Water Pollution Control Administration

WATER AREA G-2 RESUME

WATER SUPPLY REQUIREMENTS

Present

Present water supply use is large in the Huntington SMSA, and in the Portsmouth, Chillicothe, and Clermont County areas of Ohio. The Ohio River and ground water from the alluvium along the Ohio River Valley are the major sources of supply. Lesser sources with local significance are the lower Big Sandy River and wells in the Scioto Basin.

Future

Water supply needs required to meet benchmark goals of area development can be satisfied from the present significant water supply sources. Should significant development occur in the extreme northern and southern portions of the area additional water supply sources would need to be developed. In the Kentucky counties not bordering the Ohio River, water from Cave Run Reservoir or development of new impoundments would be the most promising sources of supply.

WATER POLLUTION CONTROL

Water Quality Problems

The Ohio River is generally of good quality as measured by most parameters. Bacterial pollution, taste and odor, and fish flesh tainting substances and oil pollution are intermittent problems. The lower Big Sandy is affected by taste and odor producing substances. The Scioto River is degraded by organic wastes, much of which originate in the Chillicothe, Ohio, area.

The Little Sandy River and the small streams of the basin are generally of suitable quality to protect uses.

Water Pollution Control Program

Present problems indicate need for a short-term program to implement secondary treatment and chlorination of municipal wastes for control of bacterial pollution, a program to identify and control taste and odor and fish flesh tainting substances, and a program to implement control of oil pollution.

The considerable economic growth that would be attendant with meeting benchmark goals of development indicates a long-term program of emphasis on in-plant control, flow regulation, and advanced waste treatment. Economic studies key much of the development to industrial expansion mainly along the Ohio main stem with considerable growth in the chemical industry.

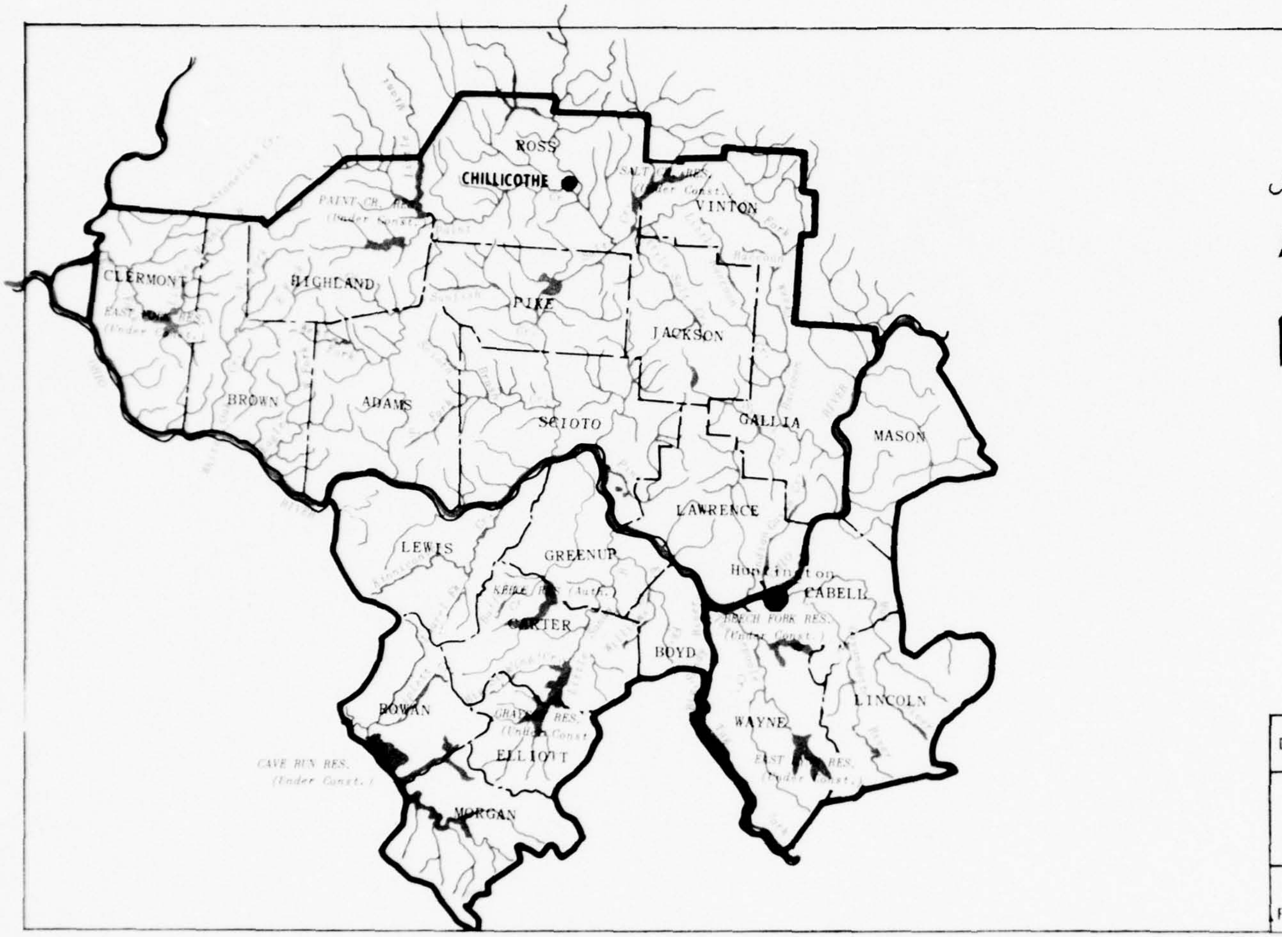
Table G-2

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
460	800	1550	3100

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
1200	2500	5300	13,300



Development of Water Resources in Appalachia

Appendix D
WATER AREA G-2 MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

WATER AREA G-3 RESUME

WATER SUPPLY REQUIREMENTS

Present

The water area G-3 present water use is largely from surface sources supplying the industrial complex in the Charleston area. The Kanawha River provides virtually all the water used in the Charleston area. Other important water supply sources are the Ohio River and the associated alluvium in the northern portion of the water area. Lesser sources are from Elk, Coal, and Pocatalico Rivers.

Future

The water supply needs derived from the benchmark goals indicate a growing pressure on the Kanawha River in the Charleston area to meet industrial needs. Since 97 percent of present industrial use in the Charleston area is for cooling purposes, continued expansion would either increase stream temperatures or require off-stream cooling facilities. Use of cooling towers would greatly reduce gross water use, but would result in a greater consumptive use of water from evaporation.

WATER POLLUTION CONTROL

Water Quality Problems

The major water quality problem in the area is in the Kanawha River below Charleston. Organic wastes result in no dissolved oxygen for the warmer months of most years. The Ohio River is generally of good quality. The lower reach of the Little Kanawha River is degraded by industrial wastes. This stretch of the Little Kanawha has reduced assimilative capacity from being in the backwater of the Ohio River lock and dam system. The Pocatalico River is degraded by brine discharges from oil wells in the drainage basin.

Water Pollution Control Program

For the Kanawha River, an intensive pollution control program will be necessary to achieve more than limited uses. Flow regulation, in-plant control, and advanced levels of waste treatment will in all probability be required. As carbonaceous and nitrogenous oxygen demands are brought under control, nutrients may become of major concern.

The Ohio River should be capable of assimilating the adequately treated wastes that are directly discharged from this area. Disinfection of municipal wastes is necessary to protect recreational and aesthetic values. Nutrient control may be expected to be of greater importance as the area increases in population and industrial activity.

The Pocatalico River brine problem is presently under study with permit holders discharging into injection wells. The extent to which this will be successful as a control is not presently known because of lack of sufficient operating experience to determine the capability of the geologic formation to satisfactorily accept the brines without either contaminating fresh water aquifers or an inability to receive the brines.

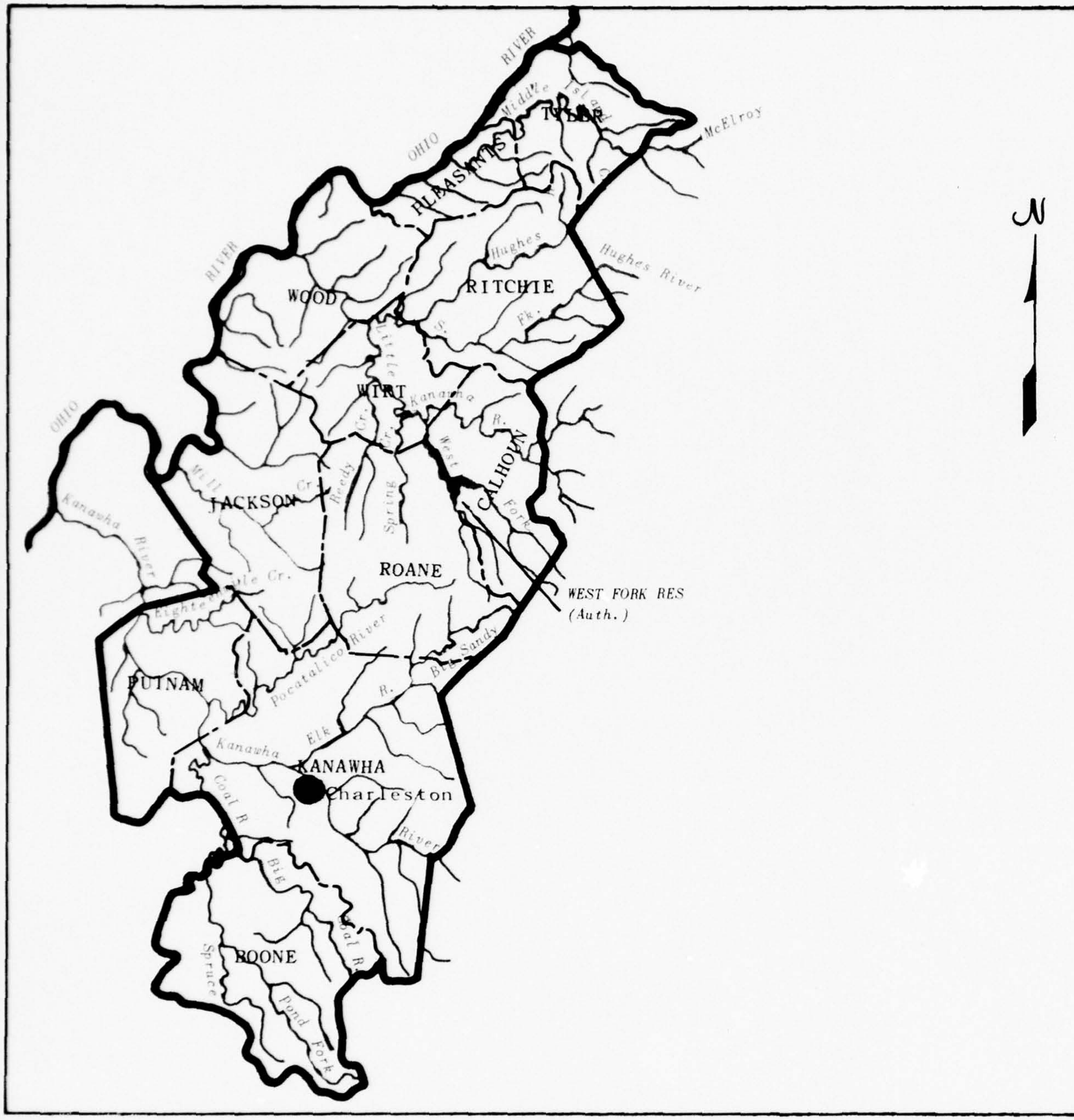
Table G-3

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
1050	1400	2600	4400

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
9200	17,300	28,600	33,100



Development of Water Resources in Appalachia

Appendix D

WATER AREA G-3 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA G-4 RESUME

WATER SUPPLY REQUIREMENTS

Present

Present water supply requirements are met almost equally from ground water and surface sources. The largest water use is in the Logan and McDowell County areas of West Virginia, which accounts for about 60 percent of the population served from central systems and about 50 percent of the water use. Other water use is widely dispersed between the many small- and moderate-sized communities in the water area.

Future

The benchmark goals of development would require significant development of water resources to meet needs. The most likely alternates to satisfy needs would depend on the location of economic growth areas. The proposed Royalton Reservoir in the Licking Basin has a preliminary allocation of 2.2 mgd for water supply purposes. The Levisa Fork and Big Sandy River areas can be served from the considerable reservoir development already completed or under construction (Yatesville, Paintsville, Dewey, Fishtrap, and Flanagan Reservoirs) with reallocation of storage or with additional construction. Significant economic development in the Tug Fork area would require resource development with impoundment of surface water and expansion of ground water supplies, the most probable solutions. The Guyandotte River area appears to have sufficient ground water to support moderate expansion; however, development of surface supplies by impoundment would probably be required to support a major water using industry.

WATER POLLUTION CONTROL

Water Quality Problems

Present water quality is degraded by coal fines discharged to streams in the Levisa Fork, Tug Fork, and Guyandotte River areas. Lack of secondary treatment results in some organic and bacterial pollution during low flow periods below the larger upstream communities not now having secondary treatment. Mine drainage pollution is a problem in localized stream reaches and is an intermittent problem throughout many streams, mainly in the form of mineralization. For more detail of mine drainage pollution problems see Appendix C.

Water Pollution Control Program

Control of coal washery waste pollution requires construction and operation of sedimentation facilities and proper storage of removed solids to prevent washing out during periods of heavy rainfall.

In the Levisa Fork Basin secondary treatment and water quality control storage provided or planned in Yatesville, Paintsville, and Fishtrap Reservoirs will allow significant economic development without serious effect on water quality. As in other portions of the water area, location of a "wet industry" with major organic loading to the streams such as a 200 ton per day pulp mill would require a consideration of measures including strict in-plant control, advanced waste treatment, and additional flow regulation.

The Tug Fork and Guyandotte Basins have a much lower assured flow than the lower Levisa Fork and Big Sandy. Therefore, major development in the "wet industry" category would require careful consideration of the various methods of in-plant control flow regulation, and advanced waste treatment to protect water quality.

Water quality control needs for the Licking River in the Salyersville and West Liberty area were presented in a June 1967 report of FWPCA on the Royalton Reservoir project. The estimated streamflow needs for assimilation of residual wastes after secondary treatment were projected to be 2.5, 7.6, and 14.3 cfs for the years 1980, 2000, and 2020, respectively.

The pollution control program as it relates to mine drainage is described in Appendix C.

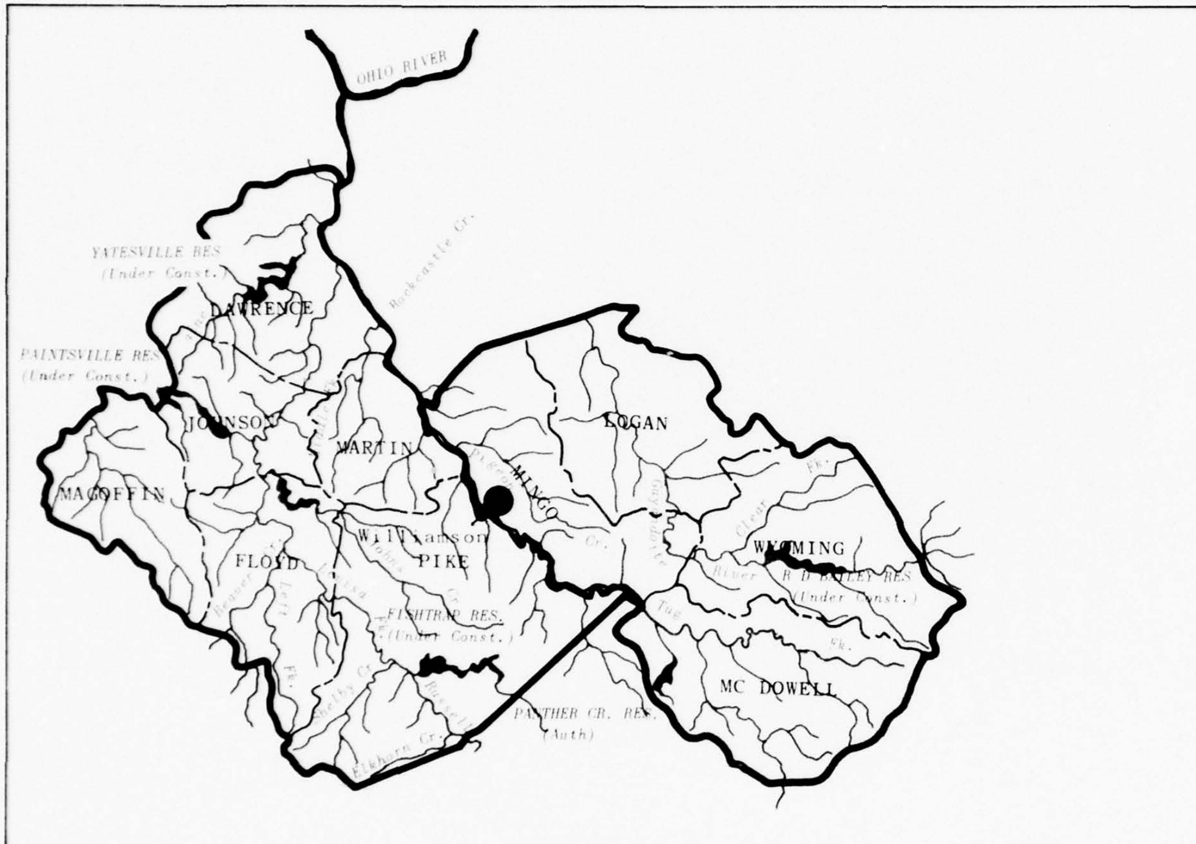
Table G-4

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
12	100	170	260

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
70	300	480	1250



Development of Water Resources in Appalachia

Appendix D
WATER AREA G-4 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA G-5 RESUME

WATER SUPPLY REQUIREMENTS

Present

Present water supply requirements in water area G-5 are met predominately from surface water supplies except in the Fayette and Mercer County, West Virginia, and Giles County, Virginia areas. Water use is highly dispersed in this area with no predominate area of use.

Future

The existing base flows in the New and Kanawha Rivers can provide water supply needs to meet the benchmark goals of development. Should significant development occur remote from these main stem areas, reallocation of storage in Sutton, Tygart, Summersville, Bluestone, or Rowlesburg Reservoirs could meet certain area needs. Development in areas remote from existing sources of supply could be served by local impoundments.

WATER POLLUTION CONTROL

Water Quality Problems

Present water quality in the New and Kanawha River reaches in water area G-5 is generally excellent and suitable for all legitimate uses. Some of the smaller tributaries throughout the water area are affected by mine drainage; however, mine drainage is of much lesser magnitude than in counties directly to the north of this area. For more information on mine drainage see Appendix C.

Water quality problems from residual organic wastes are localized problems below communities on small streams.

Water Pollution Control Program

The benchmark goals of development indicate that the main stem reaches can be protected by secondary treatment of biodegradable wastes and chlorination of municipal effluents.

Where problems exist on small streams or where significant development occurs in upstream areas, in-plant control, flow regulation, and advanced waste treatment measures will need to be considered to protect water quality.

Mine drainage problems are discussed in detail in Appendix C.

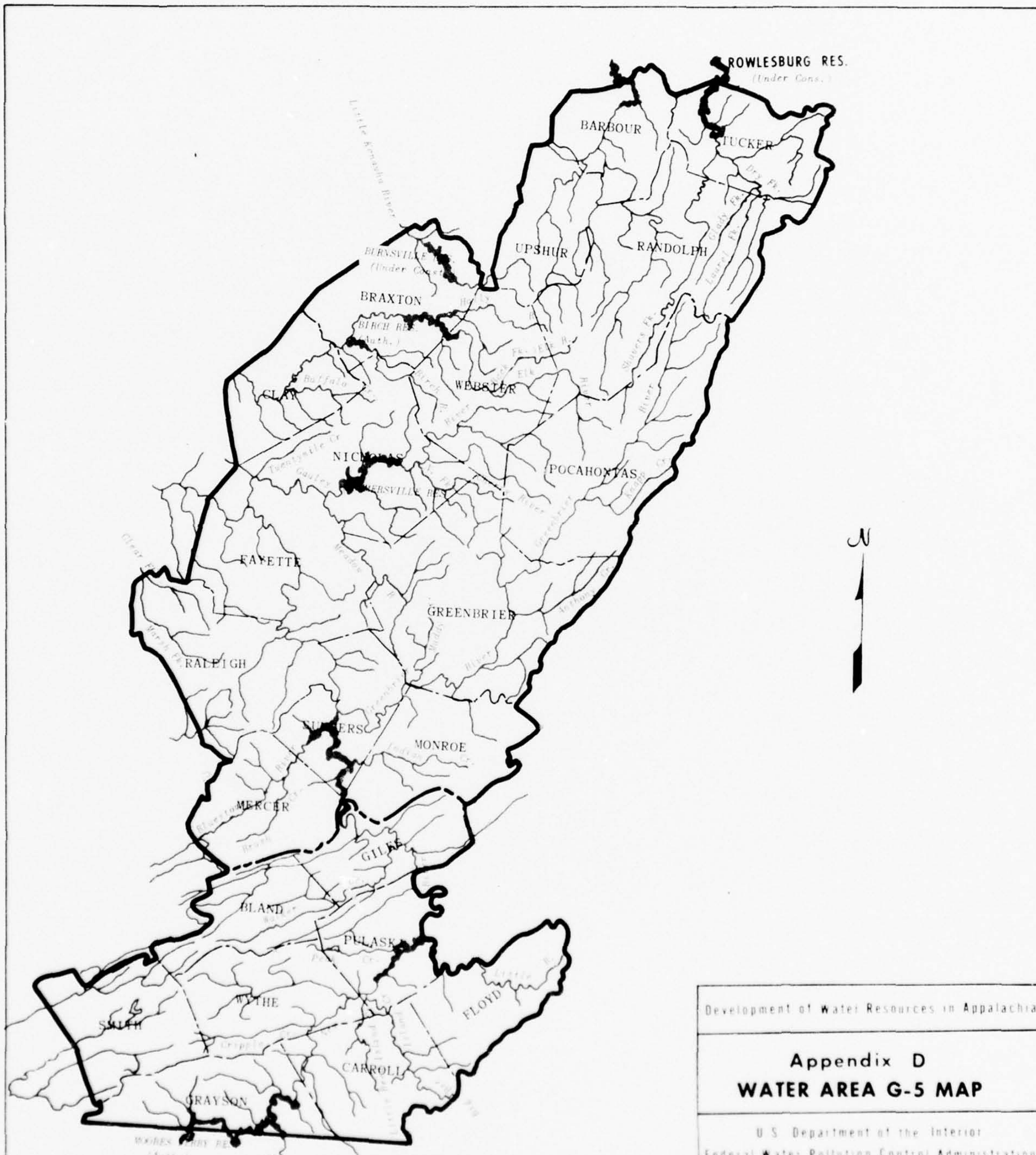
Table G-5

Water Supply Needs in Million Gallons per Day for
Municipal and Industrial Use
to meet Benchmark Goals

1960	1980	2000	2020
100	170	200	300

Untreated Waste Loadings (P.E. in 1,000's)
Accruing from Benchmark Goals

1960	1980	2000	2020
300	470	700	1,150



Development of Water Resources in Appalachia

Appendix D
WATER AREA G-5 MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

WATER AREA H RESUME

WATER SUPPLY REQUIREMENTS

Present

The water area H present water use is largely concentrated in the downstream counties of Clark, Madison, and Montgomery and in the mining counties of Letcher and Perry. Surface water is used almost exclusively as a source of significant quantities of water.

Future

The water supply needs derived from the benchmark goals (see Table H) indicate that development of additional water supply should be carefully considered. For the Montgomery and Clark County areas, information developed by the Louisville District Office, Corps of Engineers, indicates considerable potential for industrial development. Present and planned development for this area results in an exportation of water from the Kentucky River Basin to the Licking River Basin through the Winchester and Mount Sterling use of the Kentucky Basin as a source of supply and discharge of their sewage effluents to the Licking Basin. Cognizance must be taken of the present and projected considerable downstream use from the Kentucky River by Lexington, Kentucky. Upstream development sufficient to provide for Lexington's needs should, however, suffice for the Clark-Montgomery County area, if effluents from Winchester and Mount Sterling are returned to the Kentucky Basin at least during critical low flow periods in the future. This will require treatment levels high enough to allow reuse at Lexington.

The upstream areas should be able to obtain sufficient amounts of additional water from the Booneville, Buckhorn, Red, Falmouth, Cave Run, and Carr Fork Reservoirs with possible reallocation of storage should significant development occur in these areas.

Ground water is expected to continue to supply only a relatively small portion of the area's needs.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality in the Licking River and middle and lower reaches of the Kentucky River is generally suitable for beneficial uses. Mine drainage is a significant problem in some small streams in the Letcher, Perry, Knott, and Breathitt Counties. Reservoirs on these streams would

store water of questionable quality for support of aquatic life, recreational, and water supply uses. The severity of mine drainage pollution in the Kentucky River Basin decreases rapidly downstream as small polluted streams merge with other slightly polluted or unpolluted streams. However, the alkalinity of the water in the Kentucky River may be reduced below desirable natural levels by acid mine drainage at least as far downstream as Irvine in Estill County. (For more detail see Appendix C.) Water quality is also degraded at times below municipal waste treatment facilities on small streams throughout the area.

Water Pollution Control Program

Among existing or planned reservoirs the Red, Carr Fork, and Booneville Reservoirs have storage allocated to water quality control. This storage is planned for the Lexington and Hazard areas, but should be beneficial, and with adequate treatment, provide adequate water quality in the water area's portions of the main stem Kentucky River, South and North Forks of the Kentucky River, and Red River.

For the upstream reaches and for small streams receiving waste effluents, high levels of treatment, in-plant control, and opportunities for flow augmentation need to be given a high priority in the development of water quality control programs.

The pollution control program as it relates to mine drainage is discussed in Appendix C.

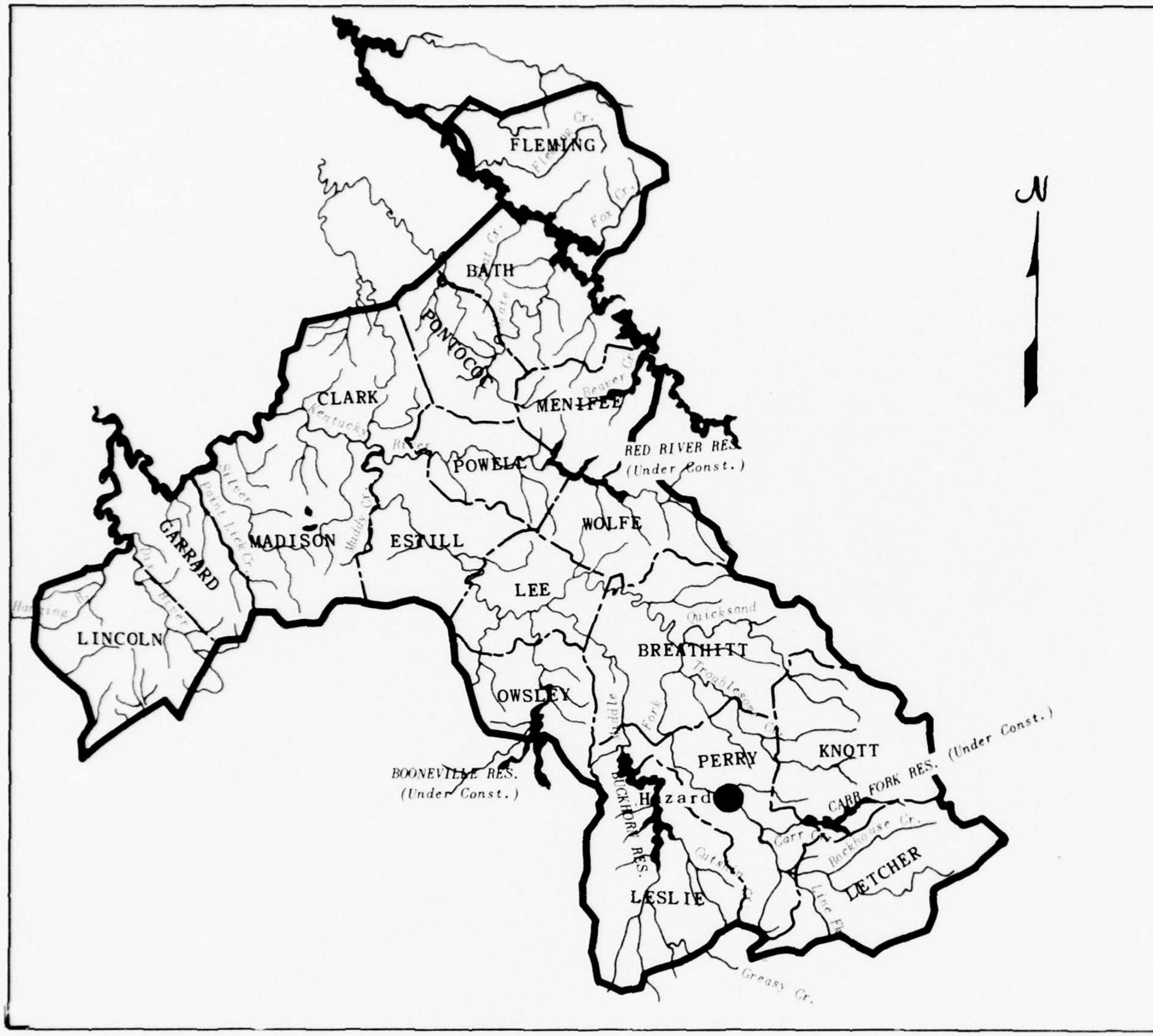
Table H

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
6	22	80	130

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
85	150	400	750



Development of Water Resources in Appalachia

Appendix D
WATER AREA H MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

WATER AREA I-1 RESUME

WATER SUPPLY REQUIREMENTS

Present

The water supply requirements to meet benchmark goals are shown in Table I-1. In water area I-1 water use by municipalities and industries is widely dispersed between the many small communities in the area, with no single predominant area of present use. Surface water sources are used almost exclusively for satisfying the municipal and industrial demands.

Future

The water supply needs derived from the benchmark goals indicate that on an areawide basis present base flows plus storage in existing reservoirs or those under construction or advanced planning (Wolf Creek, Green River, Laurel River, Booneville, and Dale Hollow) are capable of satisfying the total 2020 need possibly with minimal reallocation of storage. Should economic factors other than present water supply availability result in significant development in areas not easily supplied by existing sources or where unused water resources exist, additional development of water supply would be indicated. These potentially water supply deficient areas would appear to be largely limited to the upper Cumberland River and its tributaries above the mouth of Laurel River. Even then the total needs to meet benchmark goals are not of such a magnitude that storage of more than a small fraction of the total need would have to be developed for any growth location, since much of the growth could be supported from existing or soon to be constructed water resource developments largely in the western portion of water area I-1. Ground water is not generally a significant potential source of supply and major resource development for water supply purposes could be expected to be derived from surface sources.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality in all major streams in the area is generally suitable for beneficial use. Mine drainage is a significant problem in some small streams in McCreary, Whitley, Laurel, Knox, Bell, Clay, and Harlan Counties. Reservoir developments on these streams would impound water of questionable quality for aquatic life, water supply, and recreational uses. (See Appendix C)

Water Pollution Control Program

Among existing or planned reservoirs only the Green River Reservoir and Martins Fork Reservoir have storage allocated to water quality control which would beneficially affect the water area by providing quality respectively for the Green River in the Green County area, and the Cumberland River in the Harlan County area.

The population equivalent loading indicated by benchmark goals (see Table I-1) indicates a need to be concerned with in-plant control, high levels of treatment, and opportunities for flow augmentation, except for the Cumberland River below Wolf Creek Reservoir and the Green River in Green County. For these stream reaches secondary treatment or its equivalent for industrial wastes along with in-plant controls should allow assimilation of wastes without water resource development in excess of that now provided. The pollution control program as it relates to mine drainage is discussed in Appendix C.

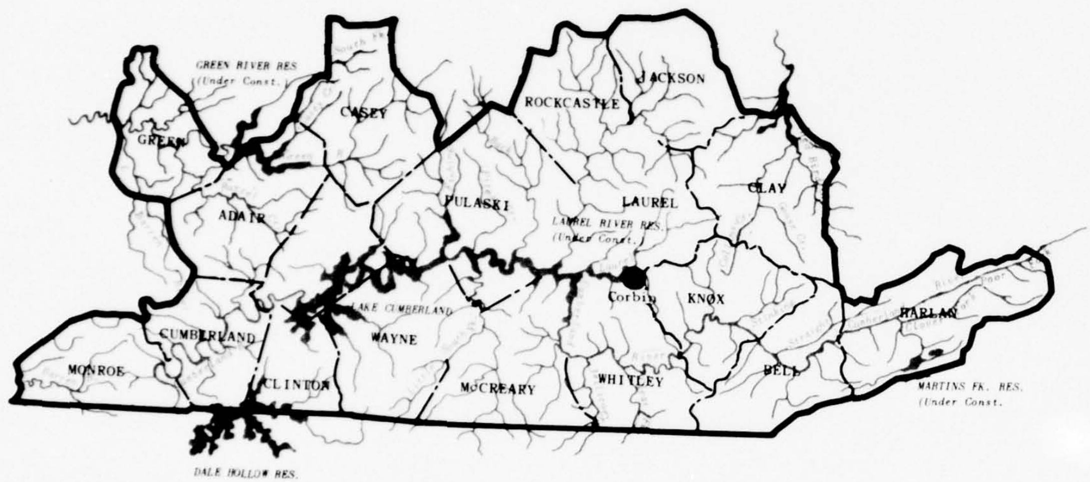
Table I-1

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
10	44	110	200

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
120	260	540	950



Development of Water Resources in Appalachia

Appendix D

WATER AREA I-1 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA I-2 RESUME

WATER SUPPLY REQUIREMENTS

Present

In water area I-2 water use by municipalities and industries is widely dispersed between the many small communities in the area, with no single predominant area of use. Surface sources are utilized for most of the total present water use.

Future

The water supply needs derived from the benchmark goals (see Table I-2) indicate that on an areawide basis present base flows plus storage in existing reservoirs or those under construction or advanced planning (Center Hill, Dale Hollow, and Cordell Hull) are capable of satisfying the total 2020 need with possibly minimal reallocation of storage. Should economic factors other than present water supply availability result in significant development in areas not easily supplied by existing and planned sources or where unused water resources exist, additional development of water supply would be indicated. These potentially water deficient areas would appear to be largely limited to the Cumberland, Fentress, and eastern portions of White, Putnam, and Overton County areas, including Cookeville.

Ground water is not expected to economically provide the quantities of water necessary for significant development in the area.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality in the Cumberland and Caney Fork Rivers is of a quality such as not to limit beneficial uses. Both the West and East Forks of the Obey River are affected by mine drainage. The West Fork is most severely affected at and for a distance below the mouth of Cub Creek. The East Fork Obey River is the stream within Tennessee most severely affected by mine drainage based on surveys in 1966. For a more detailed discussion of mine drainage see Appendix C.

Water Pollution Control Program

Based on the Framework Report on Water Supply and Water Quality Control Problem Areas of the Ohio River Basin (Appendix D, Ohio River Basin Comprehensive Survey) with provision of secondary treatment at Nashville and elsewhere and adequate control of industrial wastes, no

advanced waste treatment of flow augmentation measures are expected to be necessary to the year 2020 to provide adequate water quality in the Cumberland River. Levels of development indicated to meet benchmark goals in the I-2 area would not change the above conclusion. However, development in the headwater eastern and southeastern portions of the area would require application of measures including in-plant control, high levels of treatment, and flow regulation to assure protection of the water resources of the area. The pollution control program as it relates to mine drainage is discussed in Appendix C.

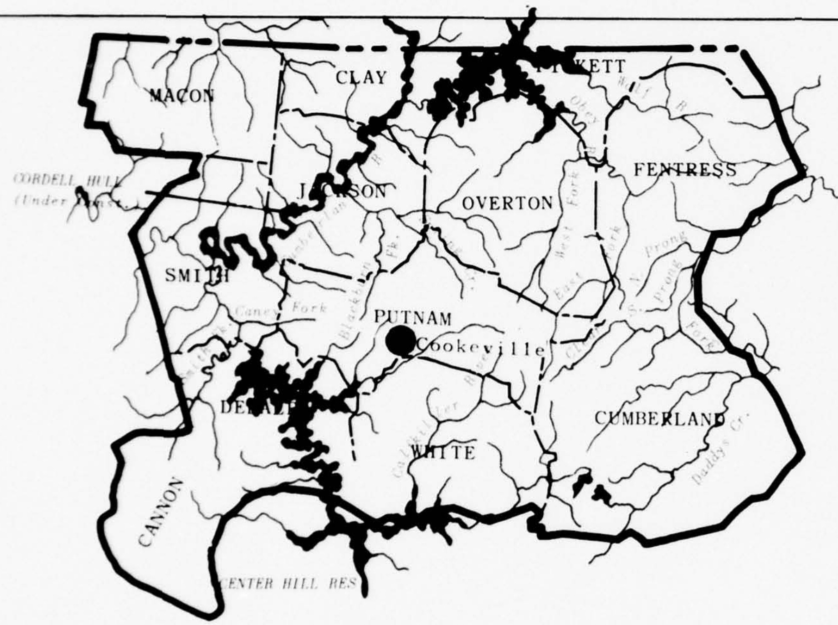
Table I-2

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
6	13	37	75

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
65	100	230	450



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Development of Water Resources in Appalachia

Appendix D
WATER AREA I-2 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA J-1 RESUME

WATER SUPPLY REQUIREMENTS

Present

The major part of this water area lies in the Valley and Ridge province where limestone springs are the source of many municipal and industrial water supplies. Approximately 23 percent of the public water supply comes from springs and wells. Although there is an abundance of surface water in the region, its use has been limited because of economic reasons involved in its treatment. Present water use is centered largely in the areas of Bristol, Virginia-Tennessee, Kingsport, Johnson City, and Elizabethton, Tennessee.

Future

The water supply needs derived from benchmark goals (see Table J-1) indicate that on an area-wide basis, present base flow, plus possible reallocation of storage in impoundments, is sufficient to meet needs. Significant development in upstream areas would require additional development, with impounded surface sources the most probable solution.

WATER POLLUTION CONTROL

Water Quality Problems

The major pollution problems affecting the water users of this area are caused by high calcium chloride content in the North Fork Holston and Holston Rivers from industrial waste discharges at Saltville, Virginia, and by bacterial pollution from inadequately treated municipal and industrial wastes discharged into the streams. To a lesser extent, acid mine drainage causes pollution in Tazewell, Wise, and Lee Counties in Virginia.

Water Pollution Control Program

The calcium chloride pollution of the North Fork Holston River will require modifications in technology, process change, and/or advanced waste treatment measures.

With secondary treatment of biodegradable wastes, deoxygenation should not generally be a problem. Chlorination of municipal effluents can be expected to control bacterial pollution, except during high runoff periods.

The significant growth indicated by benchmark goals will require increasing attention to nutrient control to protect the recreational uses in the many impoundments in the area and downstream. As the critical growth factors are determined, and as measures to control these factors are developed, nutrient control can be expected to be implemented where, and as necessary, to protect uses.

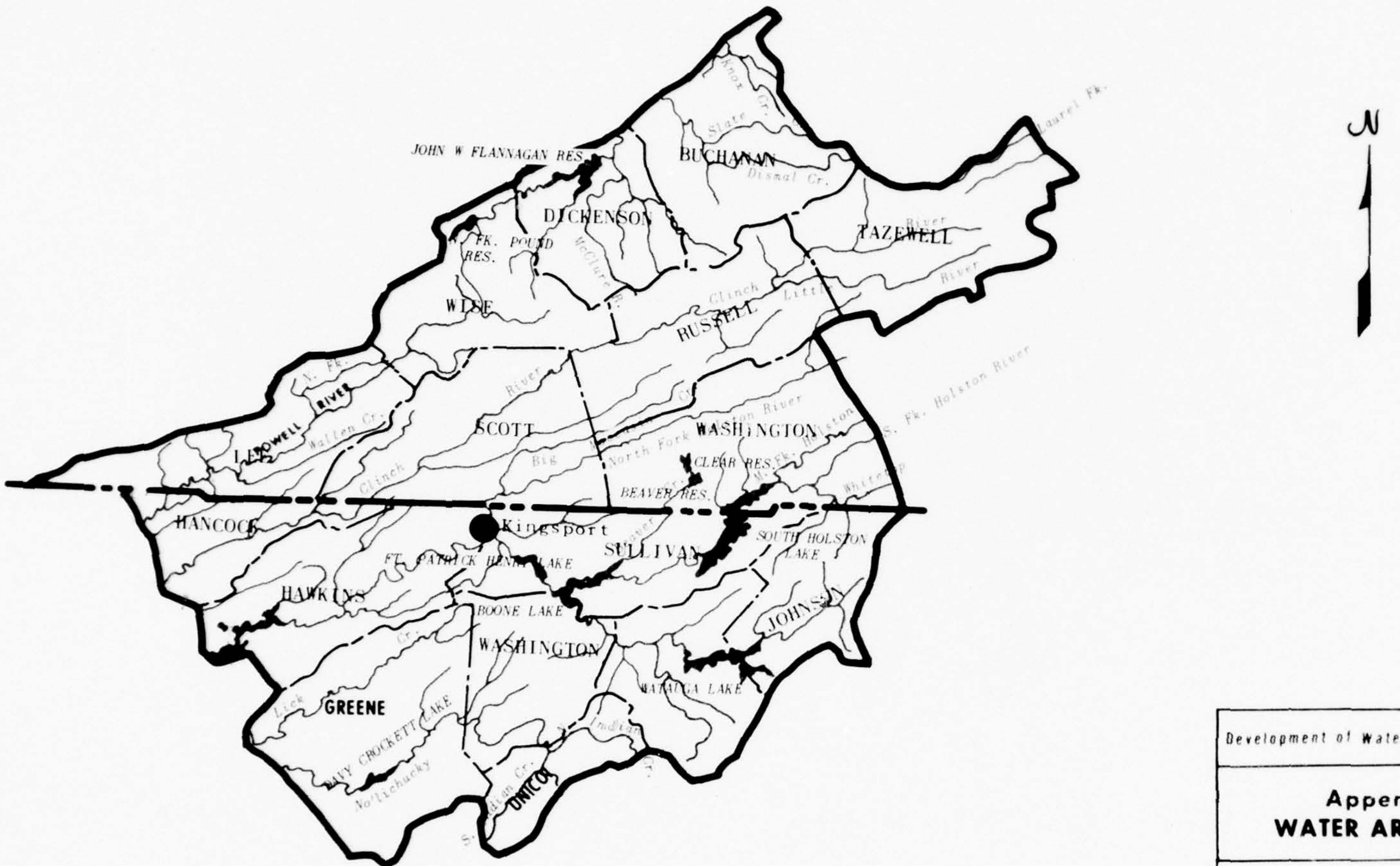
Table J-1

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
280	540	770	1150

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
850	1650	2450	3700



Development of Water Resources in Appalachia

Appendix D
WATER AREA J-1 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA J-2 RESUME

WATER SUPPLY REQUIREMENTS

Present

This water area lies in the Blue Ridge Region, which is the least productive ground water province in Appalachia. This region is underlain by dense, sparsely fractured, poorly permeable crystalline rocks that yield little water to wells. In fact, springs and wells provide only approximately 5 percent of the public water supply in this area. In general, surface water is abundant in the area. Water use is largely concentrated in the Buncombe, Haywood, and Henderson County portion.

Future

The indicated water supply needed to meet benchmark goals of development can be met by existing sources of supply, providing that impoundments are built for storage. Use of water from these impoundments is a critical necessity during low flow periods.

WATER POLLUTION CONTROL

Water Quality Problems

In past years, the main source of pollution in this North Carolina water area was a combination of untreated or inefficiently treated municipal and industrial wastes; however, great progress has been made in abating pollution in the area in recent years.

Major sources of pollution, with present estimated waste loadings prior to and following installation of approved pollution abatement measures, are a pulp and paper mill at Canton discharging wastes to Pigeon River with a P.E. of 502,000 before and 366,000 after primary treatment for all wastes; a cigarette paper and cellophane mill at Pisgah Forest discharging wastes to Davidson River, which flows into the French Broad River at river mile 191.7, with a P.E. of 360,000 before and 90,000 to 100,000 after processing and incineration of pulping liquors and use of save-alls; and a pulp and paperboard mill at Sylva discharging wastes to Scotts Creek, two miles above Tuckasegee River, with a P.E. of 366,000 before and 55,000 after processing changes and processing and incineration of pulping liquors. Note is made that the indicated efficiency at the latter mill is being obtained only about 90% of the time due to operating difficulties which are expected to be overcome in the near future.

Prior to installation of these pollution abatement measures, the wastes grossly depleted the oxygen resources, caused sludge deposits and scum blankets in pool areas, increased coliform densities to large numbers, and produced aesthetically undesirable conditions in free-flowing and impounded areas due to excessive color. While material improvements have taken place in the Davidson and French Broad Rivers, as well as in Scott Creek and Tuckasegee River, since installation of the above pollution abatement measures, Pigeon River continues to be badly degraded. The provision of secondary treatment by 1969 for all wastes from the pulp and paper mill at Canton, including the wastes from the town of Canton, will result in the protection of Pigeon River for its best usage as far as this company and the town are concerned.

Mica and feldspar mining operations in past years caused pronounced turbidity and siltation in North Toe and South Toe Rivers, but assigned water quality standards are presently being maintained. Prior to installation of zinc recovery from 3.0 mgd of zinc bearing waste and secondary treatment of 0.400 mgd of domestic waste and the strong industrial waste from a rayon and nylon plant at Enka, which reduces the P.E. from about 42,000 to 33,000, Hominy Creek was severely polluted in the 8.5-mile reach extending from Enka to the French Broad River at river mile 151.5. While there has been obvious improvement in the condition of Hominy Creek and the French Broad River, studies are needed to determine the degree of stream improvement effected and the need for additional treatment.

In past years, untreated wastes from the Asheville area caused severe degradation of the French Broad River near and below river mile 149 and of pertinent tributary streams. All wastes of the area, which have a present P.E. of 190,000, are now receiving secondary treatment with chlorination, except the small amount of waste from the Crescent Hill Sanitary District, with a P.E. of 800, which is discharged to Cane Creek without treatment. Similar treatment facilities will be provided for this waste as soon as a plant site has been secured.

In addition to their immediate effect on water quality, the above discharges contain quantities of nitrogen and phosphorus, which together with that of the projected waste discharges, can be expected to support aquatic weed growth in the river below Asheville and algal growths in Douglas Reservoir located downstream in water area J-3.

Water Pollution Control Program

Great progress has been made in pollution abatement throughout the water area since Comprehensive Pollution Abatement Plans were issued by the State of North Carolina for the French Broad River Basin in 1958, the Hiwassee and Little Tennessee River Basins in 1961, and the Watauga River Basin in 1963. Secondary treatment or its equivalent is being required throughout the area. It is anticipated that all necessary pollution abatement measures, in keeping with assigned water quality standards, will be installed by 1972. While these pollution abatement measures, with chlorination of effluents as may be required, will meet present stream standards, maintenance of higher water quality and the achievement of benchmark goals indicate a need to consider flow control and/or advanced waste treatment to protect the waters in the future.

As in other areas of the Tennessee River Basin, control of nutrients contained in existing and projected waste discharges is indicated to protect recreational aesthetic values of basin waters. Measures indicated for further study include flow control and treatment procedures for controllable discharges.

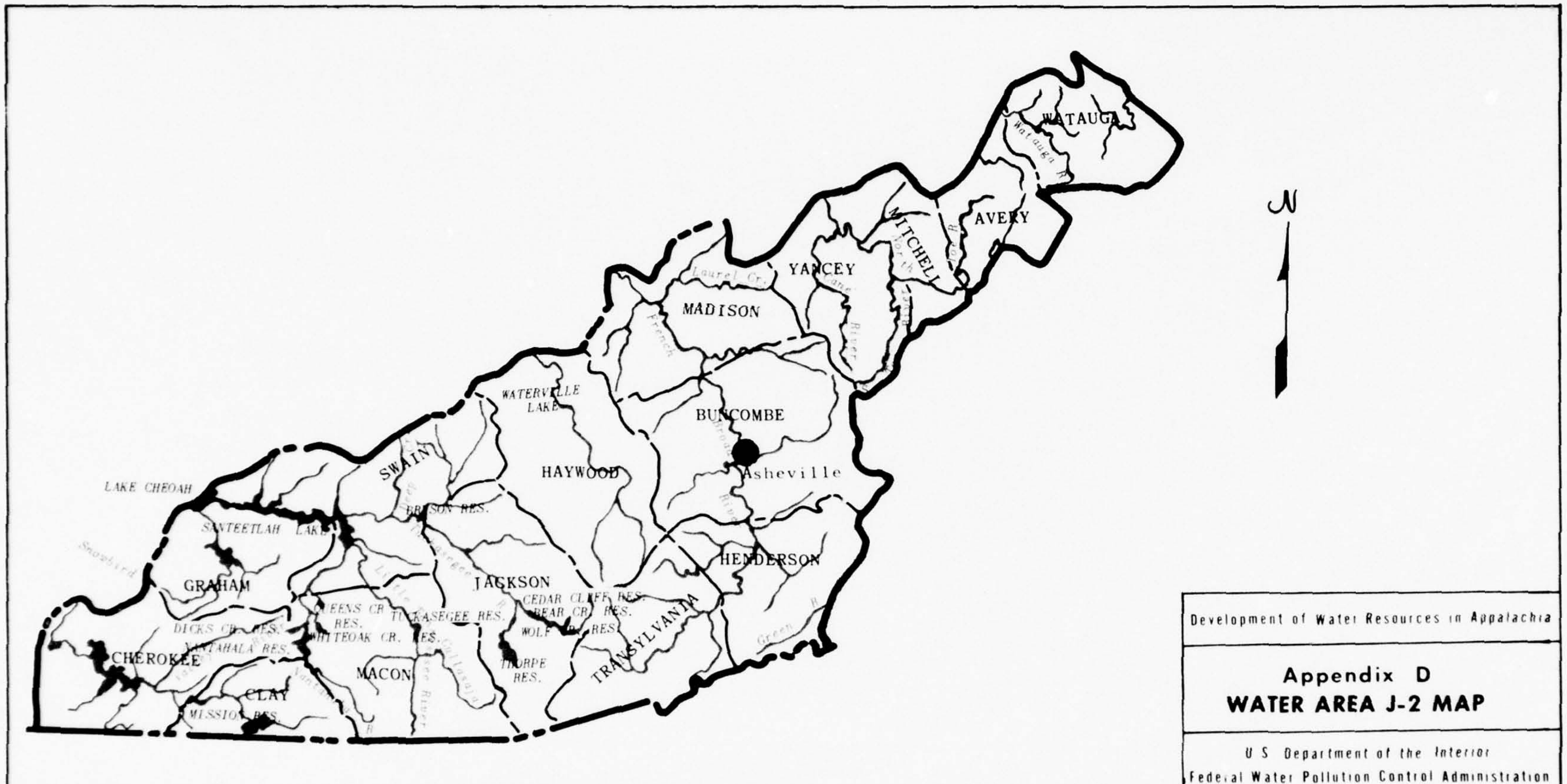
Table J-2

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
180	500	970	1800

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
1120	2150	3600	6100



Development of Water Resources in Appalachia

Appendix D
WATER AREA J-2 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA J-3 RESUME

WATER SUPPLY REQUIREMENTS

Present

The major part of this water area lies in the Valley and Ridge province where limestone springs capable of supplying many municipalities and industries are common. However, only approximately 7 percent of the public water supply comes from these springs and wells. The impoundments of the Tennessee Valley Authority and Aluminum Company of America provide abundant sources of surface water supply and are the major sources of municipal and industrial water in the area.

Future

Economic studies of the Office of Business Economics and the benchmark development goals show a very large growth in the chemical industry. When this growth is converted to apparent water needs, this water area will be the greatest water utilizer after the year 2000. The vast resources of the area could, however, supply this greatly expanded water use, provided water quality is suitably protected to allow a degree of downstream reuse.

WATER POLLUTION CONTROL

Water Quality Problems

One major problem in this water area is bacterial pollution resulting from the discharge of inadequately treated sanitary wastes. The Knoxville area is one of the major sources of pollution, and minor sources are Maryville, Alcoa, Lenoir City, Loudon, Harriman, Kingston, Spring City, and Newport. Excessive coliform densities and pathogenic bacteria have been isolated from waste discharged at Newport, Tennessee. Hardness concentrations in the Holston River caused by high calcium chloride content in the industrial wastes discharged at Saltville (water area J-1) have resulted in increased costs of treating water for domestic and industrial uses in this Tennessee water area.

Acid mine drainage causes pollution problems in Anderson, Campbell, Morgan, Roane, and Scott Counties in Tennessee. Some of the streams in Campbell and Claiborne are significantly polluted, and beneficial uses of water stored in impoundments on these streams would probably be adversely affected. In the New River drainage basin in Scott County, pollution from minor tributaries periodically lowers the alkalinity and pH in the New River at New River, Tennessee, below desirable levels and increases the iron concentration to above desirable levels.

Other problems include toxic substances and undesirable pH levels due to industrial waste discharges in the Lower Nolichucky River, and color problems in the Pigeon River arising from paper mill wastes in water area J-2. Reference is made to that portion of the report dealing with water area J-2 for information concerning progress in pollution abatement in North Carolina.

Water Pollution Control Program

For the most part, present water pollution control problems can be solved by secondary treatment of biodegradable wastes and chlorination of effluents. Future development will require increasing attention to in-plant controls, flow control, and advanced waste treatment measures. Nutrient removal and control of taste producing and toxic substances are expected to require increasing attention to accommodate increased industrial development and protect the water uses of the area.

Use of considerable quantities of water for industrial cooling could cause temperature changes deleterious to aquatic life. Careful consideration of this potentiality should be part of the area planning. Use of cooling towers could serve to protect against thermal pollution and greatly decrease intake water demands, but this would result in a greater consumptive water use.

The water pollution control program as it relates to abatement of pollution by mine drainage is discussed in more detail in Appendix C.

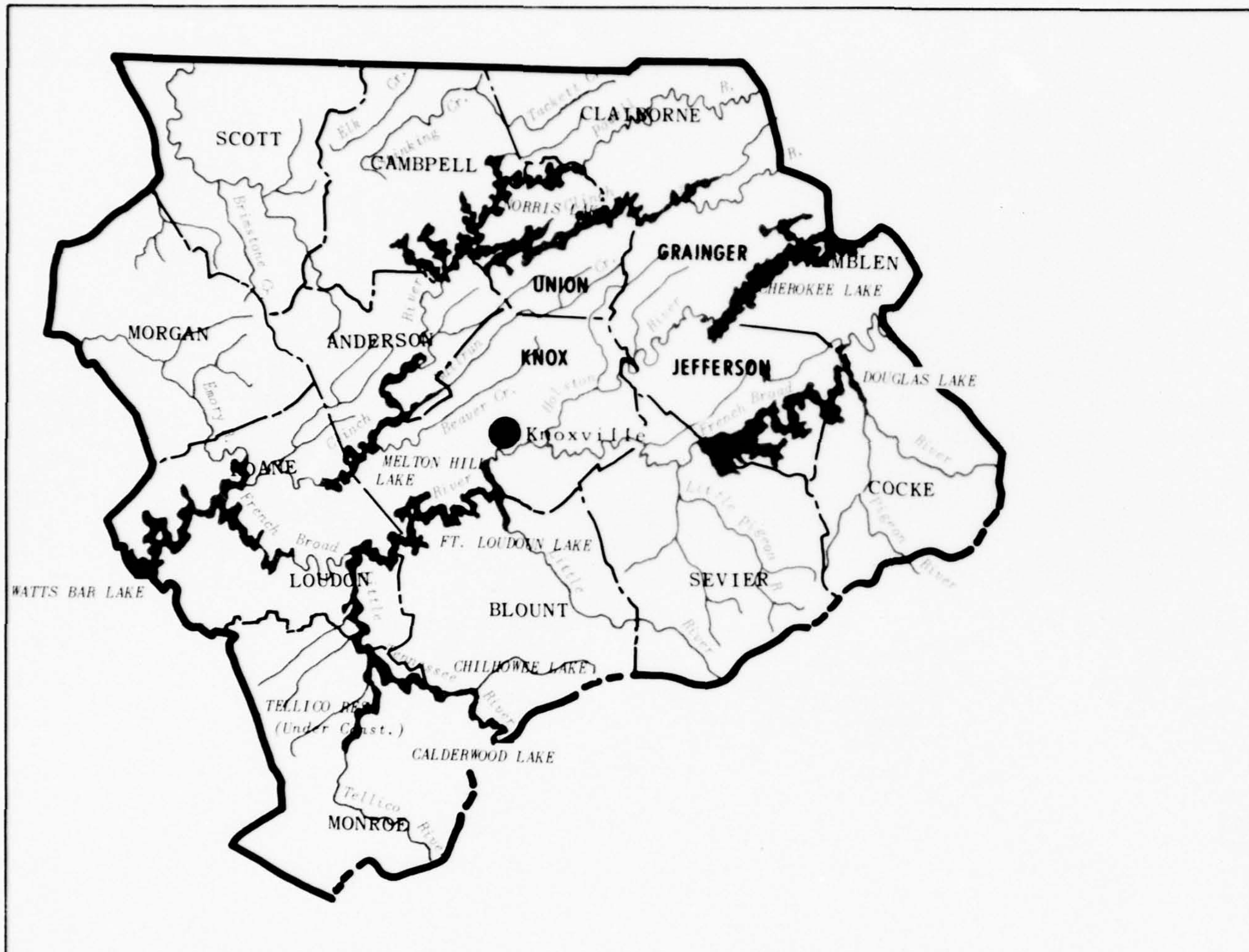
Table J-3

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
370	1350	3350	7950

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
1000	3250	7600	17,100



Development of Water Resources in Appalachia

Appendix D
WATER AREA J-3 MAP

U S Department of the Interior
Federal Water Pollution Control Administration

WATER AREA J-4 RESUME

WATER SUPPLY REQUIREMENTS

Present

Present municipal and industrial water use is largely from the impounded sources of the Tennessee Valley system. The Chattanooga SMSA is the largest user of impounded water. Approximately 10 percent of the public water supply comes from springs and/or wells of the Valley and Ridge aquiferous province.

Future

The considerable growth in water use resulting from the benchmark goals of development can be supplied from the system of impoundments in the area. Additional development for water supply purposes will be necessary only if significant development occurs in upstream areas.

WATER POLLUTION CONTROL

Water Quality Problems

Due to paper mill wastes discharged near Charleston, Tennessee, the portion of the Hiwassee River from the mill discharge to the mouth of the river is undesirable as a source of public water supply.

The wastes discharged from the Volunteer Army Ammunition Plant near Chattanooga have made the waters of Waconda Bay undesirable for recreational uses. In addition, the acid and ammonia concentrations in these wastes have resulted in several fish kills in the bay. Waste discharges from floating craft directly to Chickamauga Reservoir are a growing menace to its recreational use.

Municipalities and industries in the Chattanooga area have contaminated the Nickajack Reservoir with high bacterial loads, rendering a major portion of the reservoir unfit for any domestic or recreational uses. There is a small amount of acid mine drainage pollution in Hamilton and Sequatchie Counties, Tennessee.

Wastes from a copper production plant have given the Ocoee River an undesirable low pH.

South Chickamauga Creek and Chattanooga Creek are subject to pollution from industrial wastes creating undesirable levels of color, toxic substances, and taste and odor.

Water Pollution Control Program

Secondary treatment and chlorination of biodegradable organic wastes will help solve much of the present pollution problems.

Benchmark goals of development will require design of facilities to provide maximum in-plant control.

Development in upstream areas and on smaller streams will require consideration of flow control and/or advanced waste treatment.

Concurrent with the increased economic development, control of nutrients to protect the recreational and aesthetic value of the waters of the area is indicated.

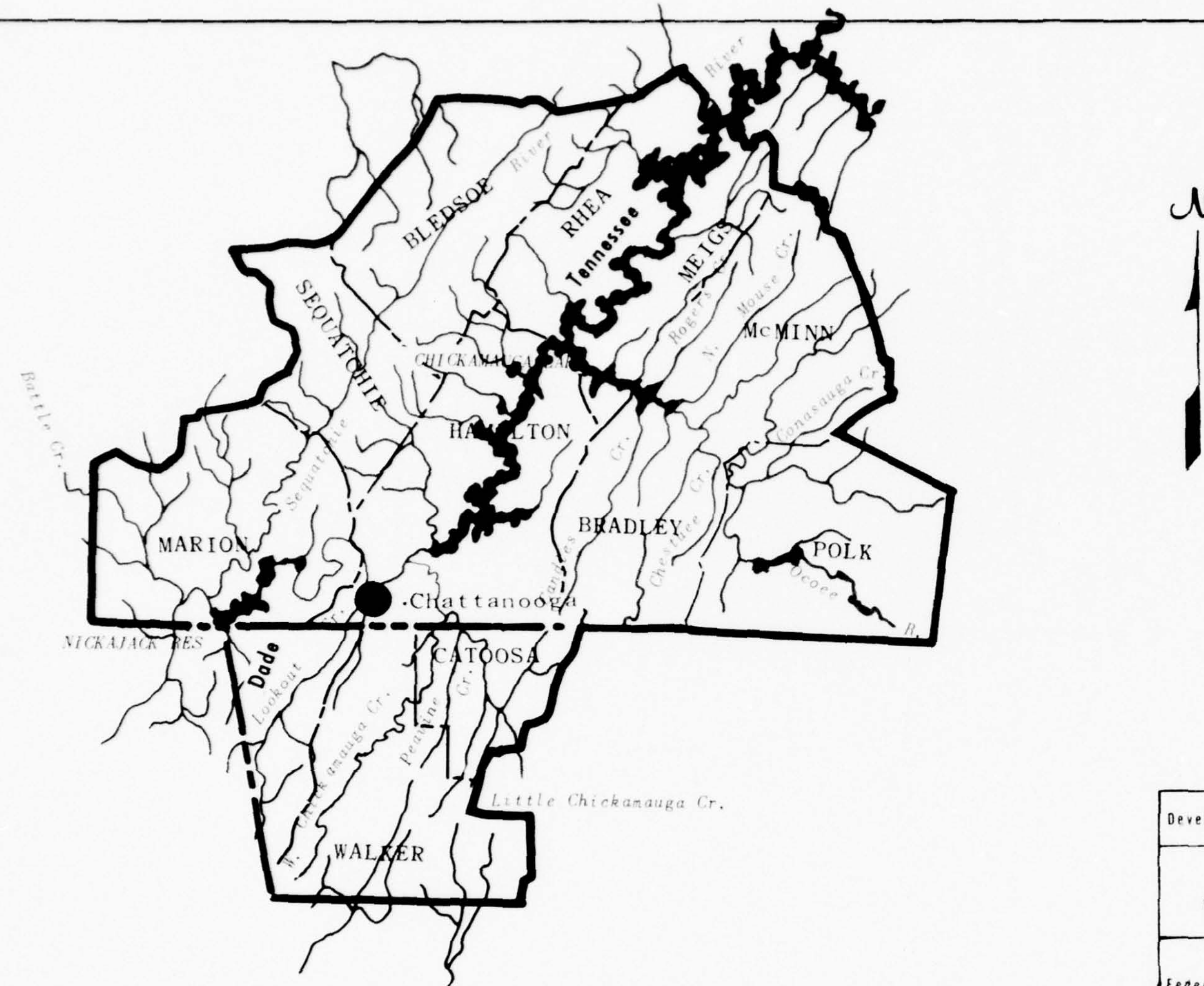
Table J-4

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
165	490	1000	2250

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
770	2000	3950	7600



Development of Water Resources in Appalachia

Appendix D
WATER AREA J-4 MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

WATER AREA J-5 RESUME

WATER SUPPLY REQUIREMENTS

Present

Approximately 17 percent of the public water supply in this water area comes from springs and wells of the Appalachian and interior low plateaus. The Tennessee River provides most of the remaining present water requirement. The Huntsville SMSA is the largest water user at present; however, water use is quite dispersed throughout the area.

Future

The benchmark goals of development indicate water needs that can be provided largely from existing sources of supply. Both surface and ground water supplies are expected to continue to be important in meeting the total needs of the area.

WATER POLLUTION CONTROL

Water Quality Problems

Water quality in this area has been degraded by inadequately treated municipal and industrial wastes. Major sources of pollution are the Bridgeport, Huntsville, Decatur, and Florence areas in Alabama; minor sources are the Stevenson, Scottsboro, Guntersville, Sheffield, Farley, Muscle Shoals, and Tuscumbia areas, also in Alabama. In many reaches of streams the oxygen levels are not sufficient to support fish life. Huntsville Spring Branch is grossly polluted with organic wastes. There is also some evidence of DDT pollution at Redstone Arsenal. Oil releases from industrial operations entering Huntsville Spring Branch interfere with surface aeration and subsequent oxidation of the heavy organic pollution load transported in the Huntsville Spring Branch. Although considerable improvement has been evident within the last two years, further progress in the treatment of the industrial wastes is required.

Water Pollution Control Program

Present pollution problems can be largely solved by providing secondary treatment and chlorinating biodegradable wastes. In-plant control measures can also play a major role in solving industrial waste problems.

The future water quality in this area will be largely dependent on measures taken in upstream areas which have jurisdiction over pollution control.

Nutrient control is expected to be an important aspect of protecting the recreational and aesthetic values of the impounded waters of the Tennessee River Basin. Such control is expected to be increasingly important as economic development progresses.

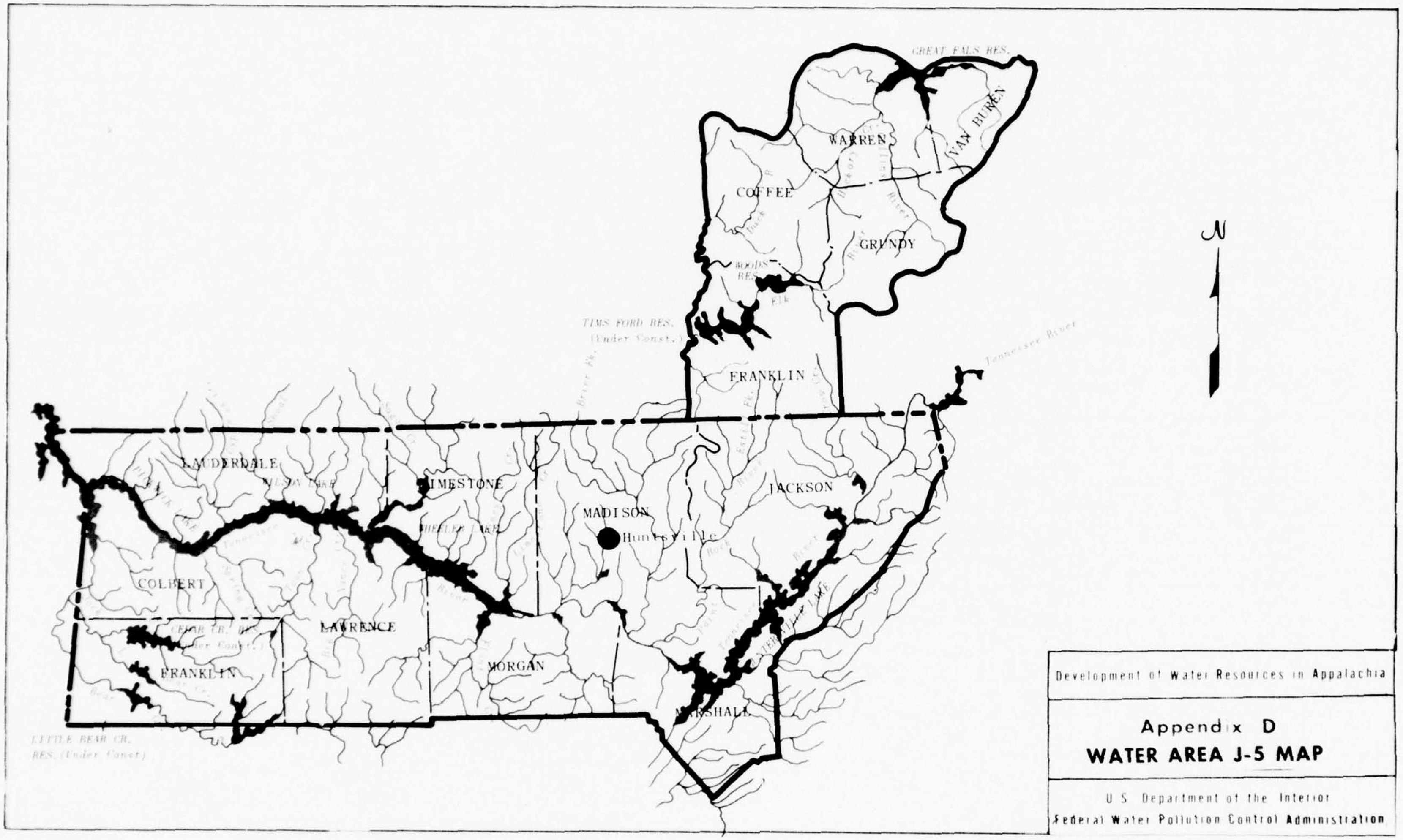
Table J-5

Water Supply Needs in Million Gallons per Day for Municipal and Industrial Use to meet Benchmark Goals

1960	1980	2000	2020
110	320	570	1350

Untreated Waste Loadings (P.E. in 1,000's) Accruing from Benchmark Goals

1960	1980	2000	2020
450	1250	2450	4900



Development of Water Resources in Appalachia

Appendix D

WATER AREA J-5 MAP

U.S. Department of the Interior
Federal Water Pollution Control Administration

SECTION V - SUPPLEMENTS TO APPENDIX D

SUPPLEMENTS TO APPENDIX D

SUPPLEMENT A - U.S. Public Health Service, Health Aspects

SUPPLEMENT B - Federal Water Pollution Control Administration, Individual Project Reports on Water Supply and Water Pollution Control

*Prepared by the Tennessee Valley Authority, with accompanying comments by the Secretary of the Interior.

SUPPLEMENT A

U.S. Public Health Service
Health Aspects

SUPPLEMENT A
HEALTH ASPECTS

Development of Water Resources for Appalachia
Department of Health, Education, and Welfare

Introduction

This supplement provides certain information regarding health aspects of water pollution control which should be considered in the Water Resources Study for Appalachia. Health aspects, as defined for this supplement, include raw water quality criteria for domestic and food processing uses, and for recreational uses. A comprehensive definition of health aspects of water resources and related land use planning and development, however, would include the consideration of problems stemming from air pollution; solid wastes disposal; radiological sources; the planning of recreational areas; the prevention and control of insect and vector problems which are commonly associated with impounded waters; and other facets that may affect the health and welfare of man.

The health aspects of the Appalachian study take on added importance as the stated purpose of the Appalachian Regional Development Act is comprehensive planning for the development and efficient utilization of water and water related resources, "giving special attention to the need for an increase in the production of economic goods and services within the region as a means of expanding economic opportunities and thus enhancing the welfare of its people."[1] The planning required to fulfill this obligation of the Act cannot be confined to increasing the production of economic goods without consideration of the effects of the plan on the environment and the health and welfare of the inhabitants in the area.

The Department of Health, Education, and Welfare is the Federal Department with the primary responsibility of evaluating the factors that may influence the nation's health. The evaluation of the health aspects of areal water resources planning and development is an important factor in fulfilling this responsibility. Planning should include measures to eliminate or minimize existing health threats and include provisions to improve the health and well-being of man.

In order that agencies participating in water resource studies may be cognizant of the health aspects, a series of "Health Guidelines for Water Resource and Related Land Use Management" have been prepared and are available upon request from DHEW, Consumer Protection and Environmental Health Service, Environmental Control Administration. These Guidelines are as follows:

Part I - Public Drinking Water Supply
Part II - Recreation Area Development
Part III - Solid Waste Management
Part IV - Vector Control
Part V - Shellfish Growing and Harvesting Waters
Part VI - Irrigation
Part VII - Radiological Health

1 Appalachian Act, Section 206a

In addition, "Health Guidelines for Raw Water Quality" have been prepared for the purpose of providing specific information to agencies involved in the planning and development of water resources where that resource is intended for use as a source for public water supply; processing of food; and for recreation. These Guidelines have been prepared in two sections which are appended to this supplement:

Section I - Raw Water Quality Criteria for Domestic and Food Processing Uses

Section II - Raw Water Quality Criteria for Recreational Use

Agencies concerned with investigating sources of water for municipal and industrial (food processing) uses are encouraged to evaluate the source in accordance with the three basic considerations included in Section I. Since biological and chemical criteria are included, the guidelines should be useful not only in the evaluation of sources for potable water supplies, but also in determining the degree of waste treatment or the need for flow regulation for water quality control.

Water resources planning as related to water supply should not be limited to an evaluation of water quality or the need for storage, but also should include an evaluation of treatment, transmission and distribution capabilities of the system. Water resources planning, and specifically water supply system planning, is not complete until the investigation and evaluation have proceeded to the point of water use. The value of an adequate source of water cannot be realized until the water is delivered to the consumer.

Agencies concerned with investigating sources of water for body contact recreational purposes are encouraged to evaluate the source in accordance with the biological, chemical, and physical raw water quality criteria included in Section II.

HEALTH GUIDELINES FOR RAW WATER QUALITY

INTRODUCTION

These health guidelines are for the guidance of Federal and other agencies concerned with the development of the Nation's water resources. The guidelines also fulfill, in part, DHEW's commitment to the Federal Water Pollution Control Administration, Department of Interior, pursuant to section 5(a) of the DHEW-Interior Interdepartmental Agreement "Health Aspects of Water Pollution Control," dated September 2, 1966, which read as follows:

> "5. Under the terms of this Interdepartmental Agreement the Department of Health, Education, and Welfare will provide advice to the Department of the Interior as follows:
>
> (a) Recommendations on criteria for water quality standard setting based on health aspects of intended water use for drinking water supplies, shellfish and other marine food production, bathing, and other water contact activities. Recommendations will be provided and modified as new supporting data are developed."

The guidelines are prepared in two sections;

Section I - Raw Water Quality Criteria for Domestic and Food Processing Uses.

Section II - Raw Water Quality Criteria for Recreational Use.

These guidelines are subject to review and modification as new research findings and knowledge become available.

A fundamental premise to the development of these guidelines is that the effluents from domestic primary sewage treatment plants are of too variable a quality to permit effective disinfection. Where uses of the receiving waters involve intimate human contact, standards must reflect a commitment to at least secondary treatment plus effective disinfection of discharge. Intimate human contact includes, but is not limited to the following water uses:

1. Domestic water supply
2. Water contact recreation
3. Shellfish growing
4. Food processing
5. Irrigation of crops grown for direct human consumption.

SECTION .I

RAW WATER QUALITY CRITERIA FOR DOMESTIC AND FOOD PROCESSING USES

OBJECTIVE

The criteria contained in this section are designed to insure a reliable quality of raw surface or underground water resources which are to be used for domestic or food processing purposes. Varying levels of quality are identified depending on the degree of treatment to be provided. Ideally, every effort should be made to maintain water resources at as high a level of quality as possible. While the application of additional treatment processes may result in water suitable for domestic and food processing uses, the factors of safety are reduced and the health hazard potential of the water supply is increased when more polluted sources are used.

The primary objective of these criteria is to establish the level of raw water quality necessary to produce a finished water which meets the requirements of the 1962 Public Health Service Drinking Water Standards.

The Standards have been developed by the Public Health Service, and updated as needed, in connection with its responsibilities relative to the certification of potable water used by interstate carriers. These Standards constitute the essential baseline for health criteria with respect to water quality for domestic and food processing uses. They also serve as an important reference point for health criteria with respect to water quality for other uses.

The three basic considerations in the determination of suitability of raw water for the intended use are:

1. Conformance with the raw water quality criteria covering bacteriological, chemical, physical, and radiological limits.
2. A sanitary survey made by qualified public health authorities is needed to reveal health hazards in consideration of specific waters. The survey report should include recommendations for:
   a. The elimination of the health hazards found.
   b. Level of treatment needed.
3. An epidemiological evaluation to determine whether identifiable disease occurrences have been associated with specific waters. Initially, such an assessment will depend upon existing records. Plans should be made, however, for relating of the water quality and development to epidemiological surveillance on a continuing systematic basis by health authorities.

Negative findings on any one of the three aspects would raise serious questions with regard to the development and use of specific waters for human purposes.

Raw Water Quality Criteria

A. Ground Water -- To be used without treatment

1. Bacteriological Quality -- Meets Drinking Water Standards,** Section 3

2. Physical Characteristics:

Turbidity	5 units
Color	15 units
Threshold Odor Number	3 units

3. Chemical Characteristics:

Substance	Concentration (mg/l)
Arsenic (As)	0.01
Barium (Ba)	1.0
Boron (B)	1.0
Cadmium (Cd)	0.01
Carbon Chloroform Extract (CCE)	0.2
Chloride (Cl)	250
Chromium (hexavalent, Cr^{+6})	0.05
Copper (Cu)	1.0
Cyanide (CN)	0.01
Detergents (Methylene Blue Active Substances)	0.5
Fluoride (F)	
50.0-58.3°F*	1.8
58.4-70.6°F*	1.5
70.7-90.5°F*	1.2
Iron (Fe)	0.3
Lead (Pb)	0.05
Manganese (Mn)	0.05
Nitrogen (in nitrate or nitrite form)	10.0
Phenols	0.001
Selenium (Se)	0.01
Silver (Ag)	0.05
Sulfate (SO_4)	250
Total Dissolved Solids	500
Uranyl Ion (UO_2^{++})	5.0
Zinc (Zn)	5.0

*Annual average of maximum daily air temperatures
**PHS Drinking Water Standards, 1962

Substance (Pesticides)	Concentration (mg/l)
Endrin	0.001
Aldrin	0.017
Dieldrin	0.017
Lindane	0.056
Toxaphene	0.005
Heptachlor	0.018
Heptachlor Epoxide	0.018
DDT	0.042
Chlordane	0.003
Methoxychlor	0.035
Total Organophosphorous and Carbamate Compounds (expressed in terms of Parathion Equivalent Cholinesterase inhibitions)	0.1
2,4,5-TP	Individual limits = 0.1 mg/l**
2,4,5-T	Sum of any combination of chlorinated
2,4-D	phenoxy alkyl pesticides = 0.1 mg/l.**

** Short period limit only--two to three days, no more than once or twice a year.

4. Radioactivity (See Drinking Water Standards,* Section 6.)

Radium-226	3 uuc/l
Strontium-90	10 uuc/l
Gross Beta	1000 uuc/l

B. Water to be Treated by Disinfection Only

1. Bacteriological Quality:
   a. Coliform Group: Less than 100/100 ml as measured by a monthly arithmetic mean.
   b. Fecal Coliform: If fecal coliform density is measured, the above total coliform density may be exceeded, but fecal coliform density should not exceed 20/100 ml as measured by a monthly arithmetic mean.
2. Physical Characteristics:
   - Turbidity - - - - - - - - - - - - - 5 units
   - Color - - - - - - - - - - - - - - - 15 units
   - Threshold odor number - - - - - - 3 units
3. Chemical Characteristics: Meets Section A.3 above.
4. Radioactivity:

Radium-226	3 uuc/l
Strontium-90	10 uuc/l
Gross Beta	1000 uuc/l

* PHS Drinking Water Standards, 1962

C. Water to be Given Complete* Treatment

1. Bacteriological Quality:
   a. Total Coliform Density: Less than 20,000/100 ml as measured by a monthly geometric mean, or
   b. Fecal Coliform Density: If fecal coliform density is measured, the above total coliform density may be exceeded but fecal coliform should not exceed 4,000/100 ml as measured by a monthly geometric mean.
2. Physical Characteristics:
   a. Color - - - - - - - - - - - 75 color units
      (This limit applies only to non-industrial sources; industrial concentrations of color should be handled on a case-by-case basis and should not exceed levels which are treatable by complete conventional means.)
   b. Odor - - - - - - - - - - - 5 threshold numbers
      Turbidity - - - - - - - Variable
      (Factors of nature, size, and electrical charge for the different particles causing turbidity require a variable limit. Turbidity should remain within a range which is readily treatable by complete conventional means; it should not overload the water treatment works; and it should not change rapidly either in nature or in concentration where such rapid shifts would upset normal treatment operations.)
3. Chemical Characteristics: Meets Section A.3 above. Minor deviations can be considered on an individual basis for such chemicals as iron and manganese, when the water supply treatment process will reduce the chemical concentration in the finished water to or below the specified limit.
4. Radioactivity:

Radium-226	3 uuc/l
Strontium-90	10 uuc/l
Gross Beta	1000 uuc/l

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* Includes Coagulation, Sedimentation, Rapid Sand Filtration, and Pre- and Post-Disinfection

SECTION II

RAW WATER QUALITY CRITERIA FOR RECREATIONAL USE

OBJECTIVE

The criteria contained in this section are designed to insure a desirable quality of raw water resources which are to be used for body contact recreational purposes. Ideally, every effort should be made to maintain water resources at as high a level of quality as possible. The bacteriological levels specified are those which represent the best knowledge on the subject at the present time, and are subject to revision as new research information becomes available. The chemical and physical levels specify an aesthetically satisfactory water as well as a safe water.

RAW WATER QUALITY CRITERIA

These guidelines include biological, chemical, and physical quality criteria for body contact recreational use. Final judgment on the acceptability of the use of any water classified under these guidelines should also include consideration of the significance of the findings of a complete survey and continuous surveillance of possible hazards as well as appropriate safety considerations.

Biological

The fecal coliform density should not exceed a geometric mean of 200/100 ml with a sampling frequency of 5 samples per month taken during peak recreational use. Not more than 10 percent of the samples' fecal coliform densities should exceed 400/100 ml.

Chemical

The water should contain no chemical which could cause toxic reaction if ingested or irritation to the skin or eyes. The water's pH should be within the range 6.5-8.3.

Physical

The water's color should not exceed 15 standard units and its turbidity should not exceed 30 standard units. Maximum water temperatures should not exceed 85°F (30°C).

SUPPLEMENT B

Federal Water Pollution Control Administration
Individual Project Reports
on Water Supply and Water Pollution Control

SUPPLEMENT B
INDIVIDUAL PROJECT REPORTS
ON WATER SUPPLY AND WATER POLLUTION CONTROL

Federal Water Pollution Control Administration

Introduction

Since the Appalachia study was initiated, the Water Resources Council has undertaken an extensive review of analysis procedures and reimbursement policies on the inclusion of storage for water quality management in Federal projects. The Council and the several water resource agencies concerned with this feature of water resource development are now involved in this review. On June 16, 1967, the Secretary of the Interior set forth a new policy for inclusion of storage for water quality management purposes. The Secretary has directed the Federal Water Pollution Control Administration and other Interior agencies concerned to apply the new policy to projects originating within the Department of the Interior and has recommended that it be adopted by other Federal construction agencies. While this new policy has many implications, there are two which are of particular significance.

First of all, Secretary Udall has directed that water quality benefits resulting from water resources projects be evaluated to the maximum extent possible in terms of a direct appraisal of the value of the water uses protected or enhanced. He has further recommended in his letter to the Water Resources Council and the Bureau of the Budget that costs of water quality management storage should be reimbursable on a basis comparable with local participation under other programs.

Second, he has directed the Federal Water Pollution Control Administration to give more explicit consideration to possible alternatives to flow regulation. This might permit meeting the water quality objectives with lesser amounts of storage for water quality management purposes in project design. It would also require that projects be periodically reviewed to determine whether storage originally provided for streamflow regulation could be reallocated to other uses in future years when advanced waste treatment technology becomes more economical to apply.

It is recognized that some difficulties in water resource project planning will arise during the interim period of changing and emerging policy. This new look at streamflow regulation and its contribution to water quality control is needed to make streamflow regulation a more effective tool in overall water resource development. Over the long run, it is believed that this re-evaluation of policy on streamflow regulation benefits by the Water Resources Council will make a significant contribution to the optimum development and use of our water resources.

Project reports in this section of the Appalachia report were prepared over a period of years. At this stage they reflect a good appraisal of quality control problems and of the contribution that

streamflow regulation can make to the maintenance of the quality of the Region's streams. They do not, however, reflect the Secretary's new policies with respect to enumeration of direct beneficiaries and full consideration of possible alternatives to flow regulation.

In particular, further research and development can be expected to result in some further reduction in costs of advanced waste treatment and to give greater assurance of plant reliability. In some cases, it may be found possible, through the use of a higher level of waste treatment, to maintain water quality at lower cost than is indicated in this report. Appropriate modification of specific project features could be considered, if this occurs. Other project features and area interests would need to be considered in any such changes.

In addition, since the Appalachian study was initiated, water quality standards provisions have been added to the Federal Water Pollution Control Act. The recommendations of the States were submitted to the Secretary of the Interior on or before June 30, 1967. Only a few of the standards for interstate streams had been approved by the Secretary at the time the individual project reports were completed. As a result of extensive review and consideration of fishery needs carried out in connection with the establishment of water quality standards, it appears likely that the 4 mg/l dissolved oxygen used in some of the reports as the basis for computation of flow regulation requirements is too low and that 5 mg/l should be maintained in streams designated for fishery use. An increase from 4 mg/l to 5 mg/l in the dissolved oxygen objective for the streams in the Appalachian area will either require additional storage and/or treatment or will shorten the period over which the storage presently provided in this area will be sufficient to maintain the desired water quality.

Because of the rapid changes in waste treatment technology occurring at this time, it is recommended that each of the reports which follow be reviewed and, if necessary, revised at the time of detailed project planning to reflect current technology, water quality standards, and the cost sharing policy being applied under the Appalchian program.

SUPPLEMENT B
INDIVIDUAL PROJECT REPORTS
ON WATER SUPPLY AND WATER POLLUTION CONTROL

Federal Water Pollution Control Administration

Introduction

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In particular, further research and development can be expected to result in some further reduction in costs of advanced waste treatment and to give greater assurance of plant reliability. In some cases, it may be found possible, through the use of a higher level of waste treatment, to maintain water quality at lower cost than is indicated in this report. Appropriate modification of specific project features could be considered, if this occurs. Other project features and area interests would need to be considered in any such changes.

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PART I USDA UPSTREAM RESERVOIR PROJECTS

U.S. DEPARTMENT OF AGRICULTURE
UPSTREAM RESERVOIR PROJECTS

by

Federal Water Pollution Control Administration
Ohio Basin Region

and

U.S. Department of Agriculture

U.S. DEPARTMENT OF AGRICULTURE
UPSTREAM RESERVOIR PROJECTS

The U.S. Department of Agriculture studied approximately 100 potential upstream reservoir projects in the Appalachian area. Various cooperating agencies were requested to identify water resource needs that might be satisfied by these projects. The Federal Water Pollution Control Administration prepared preliminary evaluations of the water supply and quality control needs that might be served from these projects. These evaluations are subject to revision based on a more thorough study for those potential projects that are carried to advanced stages of planning. Based on these preliminary evaluations from the Federal Water Pollution Control Administration, the following tabulation was prepared by the Department of Agriculture.

Water Sub-Region	Storage (acre-ft.) in Potential Upstream USDA Projects Studied: Recreation	M & I Water	Water Quality	Additional Beneficial
A	5,483	--	--	--
B	40,135	1,665	--	47,490
C	7,632	26,170	--	314,274
D	5,685	16,185	13,575	114,985
E	7,030	3,986	--	84,860
F	141,475	64,622	--	260,575
G	130,551	21,346	19,570	223,110
H	3,858	600	--	46,300
I	11,725	15,350	--	110,995
J	11,816	13,324	5,360	82,745
Total	365,390	163,248	38,505	1,285,334

For more information on the location and potential of these projects see Appendix A.

PART II - NORTHEAST REGION

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

PROMPTON RESERVOIR PROJECT

Delaware River Basin

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Northeast Region
Boston, Massachusetts

PROMPTON RESERVOIR

With regard to the Prompton Reservoir, we have reviewed the needs for water supply and for flow regulation for water quality control, and conclude that needs do not exist which would warrant a full scale study and summary report.

The Third Water Resources Program of the Delaware River Basin Commission, dated September 1965, describes the surface waters in the upper portions of the Delaware River Basin including the Lackawaxen River, as being of high quality, that is, generally saturated with dissolved oxygen, low in hardness, and high in clarity. Studies by the Delaware River Basin Commission project a relatively small increase in population for the Lackawaxen Basin, which suggests that future, adequately treated waste discharges will not be substantial. Therefore, the Lackawaxen River is, and should continue to be, of high quality and should not require storage releases for quality control.

Along the main stem of the Delaware River our Tocks Island Water Quality Control Report concluded that additional storage for water quality between the Tocks Island Reservoir and Trenton, New Jersey, would not be necessary prior to the year 2020. However, this report did show a need for an annual draft on storage of 642,000 acre feet for salinity control in the Delaware Estuary. A portion of this draft on storage could be supplied by the Prompton Project depending upon your allocation of multi-purpose storage among your proposed system of reservoirs in the upper Delaware Basin.

With regard to water supply needs in the Lackawaxen Basin, the Delaware River Basin Commission's recent economic projections indicate that water supplies available for use far exceed the demand projected for the year 1980. Extending the relatively small increase in both population and water demand projected by the DRBC to the year 2020, an additional but correspondingly small increase in demand would still not exceed current water supplies. If economic projections are available which would contradict this, we would be most anxious to re-evaluate future water supply needs. However, the above information leads us to conclude at this time that there is no definite water supply need to be met by the Prompton Reservoir Project.

PART III - MIDDLE ATLANTIC REGION

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

DAVENPORT CENTER RESERVOIR PROJECT

Susquehanna River Basin

Prepared for

U. S. Department of the Army
Corps of Engineers - Appalachia Study
U. S. Army Engineer District
Baltimore, Maryland

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Middle Atlantic Region
Charlottesville, Virginia

October 1967

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I. REQUEST AND AUTHORITY

The U. S. Department of the Army, District Engineer, Baltimore, Maryland, requested that the Federal Water Pollution Control Administration Regional Director, Middle Atlantic Region, prepare a report indicating the estimated flow needed to satisfy present and future water supply and water quality control requirements in strategic areas downstream from the proposed Appalachia Davenport Center Project.

Preparation of this report was authorized under the Appalachian Regional Development Act of 1965, P.L. 89-4, Section 206C.

II. PURPOSE AND SCOPE

The purpose of this investigation was to determine the need for and value of storage for water supply and water quality control in the proposed Davenport Center Reservoir. Water needs are based on population and economic projections prepared by the National Planning Association (N.P.A.) under contract with the Federal Water Pollution Control Administration and the Army Corps of Engineers.

The areal scope of this report includes the entire Charlotte Creek Basin and also the Susquehanna River extending from its confluence with Charlotte Creek near Oneonta, New York, to Owego, New York (approximately 100 miles). See location map, Figure 1.

III. SUMMARY OF FINDINGS

1. The benefits to be derived from water supply and water quality storage in the Davenport Center Project will accrue primarily in the Binghamton Water Service Area.

2. Municipal and industrial water supply requirements in the Binghamton Water Service Area are projected to increase from a current use of 36.8 mgd to 241 mgd by 2020.

3. The water quality of the Susquehanna River downstream from Binghamton, New York, is currently degraded by inadequately treated municipal and industrial wastes, and, unless corrective actions are taken, the beneficial uses of this reach of the Susquehanna River will be severely limited by future waste loadings imposed on the stream.

4. The ground water resources of the Binghamton Area (maximum yield 155 mgd) are not adequate to meet the 2020 water supply requirements of the Area.

5. The 2020 water supply requirements of the Binghamton Water Service Area could be met by providing 19,000 acre-feet of storage for flow regulation at the Davenport Center Reservoir Project. The average annual cost associated with this storage would be $930,000.

6. The stream flow required downstream from Binghamton necessary to maintain an average dissolved oxygen concentration of 5 mg/l under projected 2020 waste loads could be met by providing 33,800 acre-feet of water quality storage in the Davenport Center Reservoir Project. The average annual costs associated with this storage would be $1,020,000.

IV. GENERAL DESCRIPTION OF PROJECT

The proposed Davenport Center Reservoir is to be located on Charlotte Creek approximately five miles upstream from its mouth and one mile east of the Town of West Davenport in Delaware County, New York. Charlotte Creek Watershed is sparsely populated and almost completely undeveloped. The Towns of Davenport, West Davenport, and Davenport Center constitute the only population centers in the immediate area. The impounded drainage area is 164 square miles.

Streamflow records of Charlotte Creek at West Davenport, New York,* are available from June 1938 to September 1965. These records indicate an average discharge of 249 cfs; a minimum discharge of 4.5 cfs; and the seven consecutive day low flow, with a recurrence interval of 25 years, is 7.5 cfs.

Streamflow records pertaining to the Susquehanna River at Vestal, New York (strategic to the Binghamton and Endicott complex), indicate an average discharge of 6,176 cfs throughout the 28 years of record and a minimum discharge of 230 cfs. The seven consecutive day low flow, with a recurrence interval of 25 years, is 277 cfs.

V. PRESENT WATER SUPPLY

Present water usage downstream from the Davenport Center Project is shown in Table 1.

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* At Davenport Center prior to October 1956.

TABLE 1

PRESENT WATER USAGE

Area	Municipal Population Served	Municipal Use (mgd)	Industrial Process (mgd)	Industrial Cooling (mgd)	Total Use (mgd)
Oneonta	15,000	2.10	0.02	0.38	2.50
Sidney	6,700	1.12	0.50	0.45	2.07
Bainbridge	1,700	0.50	0.04	1.10	1.70
Binghamton*	102,600	10.62	3.61	6.03	20.26
Endicott*	37,000	4.26	1.89	3.50	9.65
Johnson City*	25,000	2.47	3.21	0.14	5.82
Vestal*	7,000	0.72	0.05	0.00	0.77
Fenton*	3,600	0.36	----	----	0.36
Kirkwood*	240	0.02	----	----	0.02
Total Binghamton Water Service Area	175,440	18.45	8.76	9.67	36.88

* Communities which comprise the Binghamton Water Service Area.

Binghamton City currently withdraws approximately 12.0 mgd from the Susquehanna River for municipal and industrial use. The other communities which comprise the Binghamton Water Service Area, i.e., Endicott Village, Johnson City Village, Vestal Town, etc., currently obtain their entire water supply from drilled wells. Ground water accounts for approximately 23.0 mgd, or 62 percent of the Area's total requirement.

VI. CURRENT WATER QUALITY

The New York State Department of Health collected a sample from Charlotte Creek at West Davenport in September 1953. This probably represents the only water quality data that is available for Charlotte Creek. The following is a tabulation of the analytical results:

TABLE 2

WATER QUALITY DATA

Charlotte Creek at West Davenport, New York

Indicator	Concentration
Turbidity	7 mg/l
Color	17
Temperature	16 °C
pH	7.7
DO	10.2 mg/l
BOD 5-day	1.2 mg/l
Chlorides	4.0 mg/l
Alkalinity	20.0 mg/l
Hardness	34.0 mg/l
Coliforms	430 MPN per 100 ml

Since there is little population or industrial development within the Charlotte Creek drainage area, the above sample is believed to be indicative of the excellent water quality that exists in Charlotte Creek.

The water quality of the Susquehanna River is degraded by the large quantities of primary and untreated waste effluents discharged from the Binghamton and Endicott Areas. Results of the stream survey in the summer of 1965 by the Federal Water Pollution Control Administration, Chesapeake Bay-Susquehanna River Basins Project, and presented in the following tabulation, show the severe degradation that occurred in the Susquehanna River downstream from Binghamton.

TABLE 3

WATER QUALITY DATA

Susquehanna River at Binghamton, New York

Indicator	Concentration
DO	0.9 mg/l - 3.8 mg/l
pH	7.7 - 8.6
BOD 5-day	9.0 mg/l - 29.0 mg/l
Coliforms/100 ml	4,000 - 200,000

Binghamton City and Endicott Village both provide primary treatment of wastes prior to discharge; whereas, Johnson City currently provides no treatment. The assimilative capacity of the Susquehanna River is, consequently, exceeded by the large waste loads discharged from the Binghamton Area. The New York State Department of Health has initiated action against Binghamton and Endicott to upgrade their existing facilities to secondary treatment. Johnson City Village is expected to connect into the Binghamton treatment plant.

VII. POPULATION AND ECONOMY

The economic projections used in this study were prepared by the National Planning Association in conjunction with the Susquehanna River Basin Study. Population trends based on these projections are outlined for the Binghamton Water Service Area as follows:

TABLE 4

POPULATION

Binghamton Water Service Area

Water Service Area	Population 1960	1980	2000	2020
Binghamton	200,300	299,000	473,000	785,000

The projected product output for the major water-using industries in the Binghamton Water Service Area are shown in the following tabulation:

TABLE 5

PROJECTED INDICES OF PRODUCTION

Binghamton Water Service Area

SIC*	Type Industry	Projected Indices of Production** 1980	2000	2020
1441	Sand and Gravel	228	805	1400
2026	Fluid Milk	332	845	1345
2013	Meat Packing	272	590	945
2086	Soft Drink	149	236	392

TABLE 5 (Continued)

SIC*	Type Industry	Projected Indices of Production** 1980	2000	2020
2023	Condensed and Evaporated Milk	241	515	840
2653	Corrugated and Solid Fiber Boxes	100	20	0
2844	Perfume and Cosmetics	270	660	1020
3251	Brick	230	370	510
3391	Iron and Steel Forging	189	350	490
3571	Computing Machines	270	670	1135
2071	Candy	133	260	370
1981	Ordinance	183	350	530
3861	Photographic Equipment	240	535	805
4011	Railroads	100	100	100
3141	Footwear	39	20	10
3729	Aircraft Parts	352	780	1175

* Standard Industrial Classification

** A base of 100 was used for 1960.

VIII. WATER SUPPLY NEEDS

Based on the projected economic and demographic trends developed by the National Planning Association, the following municipal and industrial water supply requirements are anticipated for the Binghamton Area:

TABLE 6

PROJECTED MUNICIPAL AND INDUSTRIAL WATER NEEDS

Binghamton Water Service Area

Water Service Area	1980 Water Use gpcpd	Mun (mgd)	Ind (mgd)	2000 Water Use gpcpd	Mun (mgd)	Ind (mgd)	2020 Water Use gpcpd	Mun (mgd)	Ind (mgd)
Binghamton	123	33.8	32.5	144	65.4	72.3	165	129.5	111.5
Totals Municipal and Industrial		66.3			137.7			241.0	

Future municipal water use projections were based on the assumption that present per capita water use in the Binghamton Area will experience an average increase of one percent per year.

Future industrial water supply requirements were estimated on the basis of present industrial water use and projected product output for the major water-using industries in the Binghamton Area. In the industries where studies indicated it was appropriate, the projected water supply requirements were attenuated to reflect anticipated in-plant technological changes, the increased cost of water, and other factors which would tend to decrease future industrial water use.

Although the ground water resources of the Binghamton Area are significant and could be developed to yield a maximum of 155 mgd, this yield would not be adequate to meet the projected 2020 water supply requirements of the Area (241 mgd). For the purpose of this report, therefore, it was assumed that future water supply needs of the Area would be obtained from surface water sources.

Future water supply requirements of the Area could be met by augmenting the flow of the Susquehanna River from storage in the Davenport Center Project. Table 7 shows the storage required in the proposed Davenport Center Project to meet the 1980, 2000, and 2020 water supply requirements of the Binghamton Water Service Area 98 percent of the time. Storages were determined based on water supply needs of 62 cfs, 118 cfs, and 224 cfs for the years 1980, 2000, and 2020, respectively. Industrial cooling water was not included in the projected water supply requirements.

TABLE 7

DAVENPORT CENTER PROJECT

Water Supply Storage Requirements

Year	Storage (Acre-Feet)
1980	0
2000	4,450
2020	19,000

IX. WATER QUALITY CONTROL NEEDS

Due to increased population growth and industrial expansion, the total waste loads from the Binghamton Water Service Area are expected to increase substantially over the next 50 years. The tabulation below indicates the extent of this increase prior to provision of secondary treatment (85 percent ultimate first stage BOD removal).

TABLE 8

PROJECTED WASTE LOAD

Expressed as Population Equivalents

Area	1980 Raw (PE)	2000 Raw (PE)	2020 Raw (PE)
Binghamton	254,435	446,582	723,392
Endicott	82,485	140,787	243,638

The projected waste loads were based upon the projected population and industrial growths shown in Section VII.

The stream flows needed to assimilate the projected waste loads while maintaining an average dissolved oxygen (DO) of 5.0 mg/l are shown in Table 9. The flows were determined using Thomas' step version of the Streeter-Phelps formulation of the oxygen-sag equation. A mathematical model relating temperature, dissolved oxygen, biochemical oxygen demand, and stream flow was used in this investigation.

Three levels of waste water treatment were investigated and are listed below:

Level I - 85 percent removal of 5-day BOD (conventional secondary treatment)

Level II - 90 percent removal of 5-day BOD

Level III - 95 percent removal of 5-day BOD

Level I is considered to be a minimum level of treatment and should be achieved before additional stream flow is considered as an alternative for obtaining desired water quality goals.

TABLE 9

WATER QUALITY CONTROL REQUIREMENTS

To Maintain an Average Dissolved Oxygen Concentration of 5 mg/l

Binghamton Water Service Area

Design Year	Level of Treatment	Annual Cost of Increased Treatment	Flow in CFS Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	I		95	95	95	95	110	185	198	185	150	114	95	95
	II		95	95	95	95	96	130	135	130	110	96	95	95
	III		95	95	95	95	95	97	98	97	96	96	95	95
2000	I	1,875,000	170	170	170	170	210	376	405	376	305	223	170	170
	II	885,000	170	170	170	170	170	250	270	250	210	173	170	170
	III	1,355,000	170	170	170	170	170	175	175	175	173	170	170	170
2020	I	2,980,000	308	308	308	308	390	682	740	682	560	410	308	308
	II	1,620,000	308	308	308	310	311	465	495	465	395	312	308	308
	III	2,490,000	308	308	308	310	311	320	320	320	318	312	308	308

The annual expenditures required to provide either Level II or III, over and above Level I, were obtained from a study by Frankel.* The costs of the additional levels of treatment are the total annual cost for operation, maintenance, and amortization over a 20-year period.

Based on 1980, 2020 estimated waste discharges, Table 10 shows the storage required in the Davenport Center Reservoir to maintain an average dissolved oxygen level of 5.0 mg/l, 98 percent of the time in the Susquehanna River at Binghamton, New York. Storage needs were computed on the assumption that all wastes receive secondary treatment (85 percent BOD removal).

TABLE 10

WATER QUALITY STORAGE REQUIREMENTS

Davenport Center Reservoir Project

Year	Water Quality Storage Requirements (Acre-Feet)
1980	0
2000	9,000
2020	33,800

X. BENEFITS

The water quality and water supply benefits that may be realized from the storage in the Davenport Center Project accrue primarily at and downstream from the Binghamton Water Service Area.

The water quality of the Susquehanna River downstream from Binghamton and Endicott is presently degraded, and, unless corrective measures are undertaken, degradation will become increasingly worse, limiting the potential use of the stream. In order to maintain a water quality suitable for a warm-water fishery and other beneficial uses, additional stream flow will be necessary to assimilate the projected waste loads from Binghamton and Endicott.

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* Frankel, R. J., "Water Quality Management: Engineering Economic Model for Domestic Waste Disposal," PhD Dissertation, University of California, Berkeley, 1965.

The 2020 water quality requirements of the Binghamton Water Service Area can be met by the construction of a single-purpose reservoir at Davenport Center with an annual draft on storage of 33,800 acre-feet. Similarly, a single-purpose water supply reservoir with an annual draft on storage of 19,000 acre-feet can meet the 2020 water supply needs of the Area.

The estimated cost of single-purpose reservoirs was determined by the Department of the Army, Baltimore District, Corps of Engineers, and is presented in the following table:

TABLE 11

COST OF SINGLE-PURPOSE RESERVOIR

Davenport Center Project

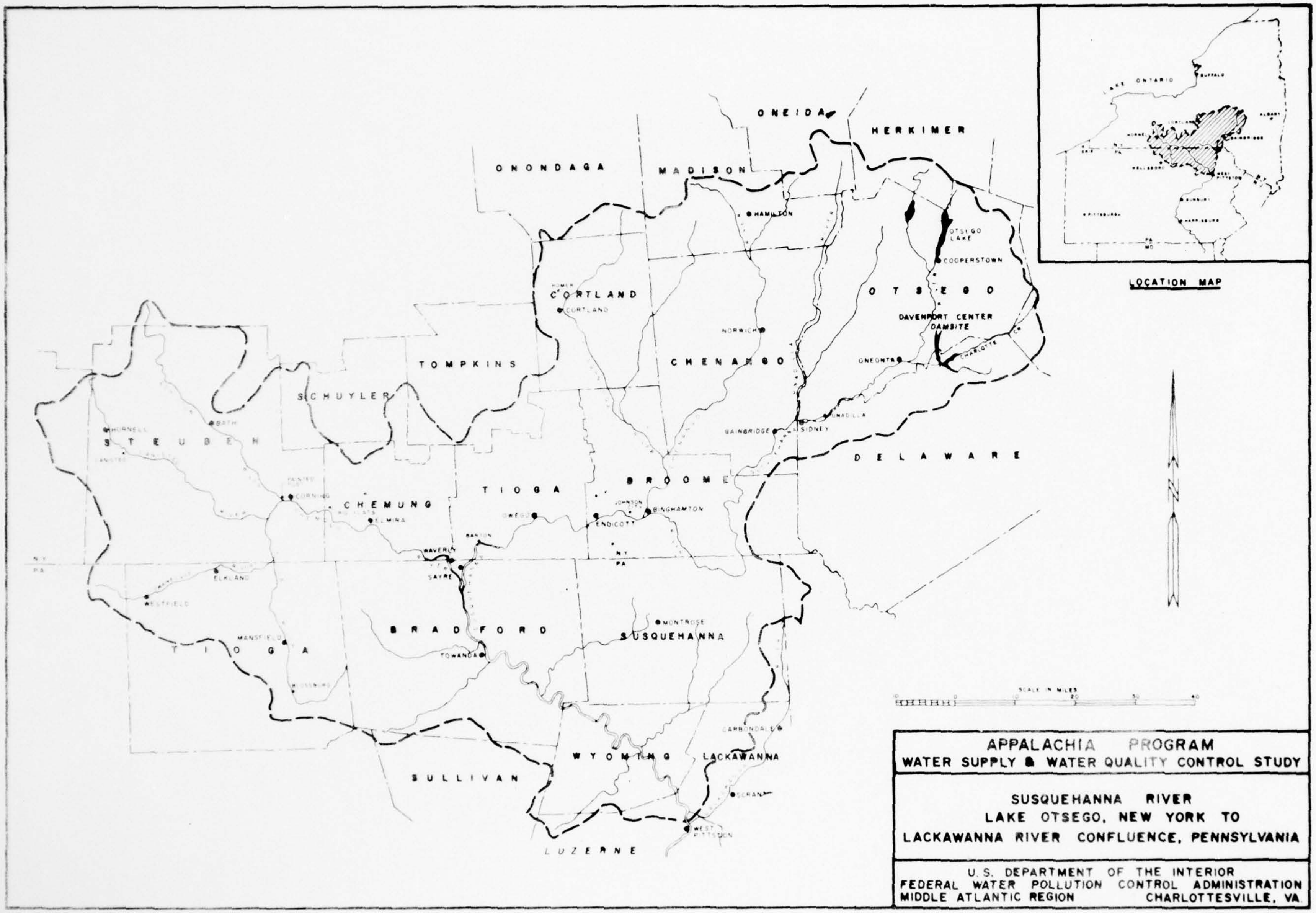
Use	Design Year	Annual Draft on Storage (Acre-Feet)	Total First Costs	Total Annual Costs*
Water Supply	2020	19,000	$18,600,000	$ 930,000
Water Quality	2020	33,800	$20,400,000	$1,020,000

* All the total annual cost values are in terms of 1967 dollars and are based on a 100-year amortization of capital costs plus estimated annual operation, maintenance, and replacement costs.

Based on these costs, single-purpose water supply and water quality control reservoirs were determined to be the least costly alternative means of meeting the requirements of the Binghamton Water Service Area.

The costs of single-purpose alternative reservoirs to meet water supply and water quality control needs are considered to be the minimum benefits of meeting these needs from storage in the Davenport Center Project.

The storage reported was determined based on the assumption that all of the low-flow augmentation storage needed to meet the water supply and water quality requirements in the Binghamton Area would be developed at the Davenport Center Project. Comprehensive water resources planning is currently underway in the Susquehanna River Basin. If the results of the comprehensive study indicate that it would be more desirable to develop all or part of the required low-flow augmentation storage at other upstream reservoir sites, the Davenport Center Project should be restudied and the storage allocations revised accordingly.



APPALACHIA PROGRAM
WATER SUPPLY & WATER QUALITY CONTROL STUDY
SUSQUEHANNA RIVER
LAKE OTSEGO, NEW YORK TO
LACKAWANNA RIVER CONFLUENCE, PENNSYLVANIA
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION
CHARLOTTESVILLE, VA.
LOCATION MAP
ONONDAGA
MADISON
ONEIDA
HERKIMER
CORTLAND
TOMPKINS
SCHUYLER
STEUBEN
CHEMUNG
TIOGA
CHENANGO
OTSEGO
DELAWARE
BROOME
BRADFORD
SUSQUEHANNA
WYOMING
LACKAWANNA
SULLIVAN
LUZERNE
OTSEGO LAKE
COOPERSTOWN
DAVENPORT CENTER DAMSITE
ONEONTA
HAMILTON
NORWICH
BAINBRIDGE
SIDNEY
BINGHAMTON
ENDICOTT
OWEGO
WAVERLY
SAYRE
TOWANDA
ELMIRA
CORNING
BATH
HORNELL
ELKLAND
WESTFIELD
MANSFIELD
MONTROSE
CARBONDALE
WEST PITTSTON
CORTLAND
N.Y.
PA.
SCALE IN MILES

FIGURE 1

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

Royal Glen Reservoir Project
Savage II Reservoir Project

SOUTH BRANCH AND NORTH BRANCH POTOMAC RIVER BASIN

Prepared for

U. S. Department of the Army
Corps of Engineers - Appalachia Study
U. S. Army Engineer District
Baltimore, Maryland

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Middle Atlantic Region
Charlottesville, Virginia

October 1967

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I. REQUEST AND AUTHORITY

The U. S. Department of the Army, District Engineer, Baltimore, Maryland, requested through a letter dated May 5, 1967, that the Federal Water Pollution Control Administration Regional Director, Middle Atlantic Region, prepare a report indicating the estimated flow needed to satisfy present and future water supply and water quality control requirements in strategic areas downstream from the proposed Appalachia Projects of Royal Glen Reservoir and Savage II Reservoir.

This report was prepared under the authority of the Appalachian Regional Development Act of 1965, P.L. 89-4, Section 206C.

II. ACKNOWLEDGMENTS

The assistance and cooperation of various governmental agencies, industrial representatives, and institutions which enabled the Chesapeake Bay-Susquehanna River Basins Project to evaluate water supply and water quality control needs were sought and are gratefully acknowledged. Cooperation was received from individuals and organizations too numerous to be listed, but special mention is merited by the following:

Maryland Department of Water Resources
Maryland State Department of Health
West Virginia Department of Natural Resources
West Virginia Pulp and Paper Company, Luke, Maryland
Celanese Corporation, Amcelle, Maryland
U. S. Geological Survey, Department of the Interior
U. S. Army Corps of Engineers, Baltimore District

III. PURPOSE AND SCOPE

The purpose of this investigation was to determine the need for and value of water supply and water quality control storage in the proposed Royal Glen Reservoir and the Savage River II Reservoir (see Figure 1).

Water needs are based on population and economic projections prepared by the Office of Business Economics, Department of the Commerce, and Corps of Engineers, Office of Appalachian Studies, Cincinnati, Ohio. These projections reflect the anticipated developmental effect of the Appalachia Program in the Area.

This report is considered supplemental to the May 1962 report[1] prepared by the U. S. Department of Health, Education, and Welfare,

Public Health Service, Region III, Charlottesville, Virginia, for the U. S. Army Engineer District, Baltimore, Maryland. Responsibility for water quality control activities was transferred from the Department of Health, Education, and Welfare to the Department of the Interior by Reorganization Plan No. 2 of 1966, effective May 10, 1966.

The scope of this report is limited to the North and South Branches and to the upper portion of the main stem of the Potomac River within the Appalachia Region (see Figure 1).

In re-evaluating the needs in the Appalachia Region of the Potomac River, no assessments were made of the water requirements outside of the Appalachia Region.

IV. SUMMARY OF FINDINGS

1. The combined population of the five major water service areas in the region is projected to increase from 77,000 in 1960 to about 163,000 in the year 2020.

2. Using 1960 as a base line, the projected indices of production for the major water-using industries indicate an anticipated industrial growth increase of over 400 percent by the year 2020.

3. The existing and potential surface and ground water resources are adequate to meet current and projected municipal and industrial water needs; hence, there is no need for reservoir storage for water supply in the South Branch and in the upper main stem of the Potomac River.

4. In the North Branch area, the two existing reservoirs and the authorized Bloomington Reservoir Project will be more than adequate to meet current and projected municipal and industrial water supply needs.

5. The Bloomington Project, which will impound waters with a normal pH range of 3.0 to 5.0, will upset the current equiponderance of the acidity and alkalinity contribution from the North Branch and Savage River, especially during the low flow months. If the mine drainage in the watershed above the project is not reduced, the effects on water quality could be evident as far downstream as Cumberland, Maryland.

6. In the South Branch and in the upper main stem of the Potomac River Watershed, there is no present nor projected need for reservoir storage for water quality control.

7. The predicted 212 cfs increase in dependable flow from Bloomington Reservoir, which is currently under construction, will be adequate to meet projected water quality control requirements of the biologically degradable waste waters in the North Branch Watershed.

V. PRESENT WATER USE

In Table 2 the water use for the five water service areas within the study area is presented. Of the approximately 145 million gallons of daily use, about 70 percent is for cooling purposes, with 25 percent for industrial needs, and the remaining five percent for municipal requirements.

The largest industrial user of water is the West Virginia Pulp and Paper Corporation, which uses the North Branch of the Potomac River at Luke as its source of process and cooling water. Of the 72 million gallons it uses daily, approximately 39 percent is for process water, with the remaining used for cooling purposes.

The Celanese Corporation in Amcelle is the second largest industrial user of water in the study area. Approximately 58 mgd of water is obtained for cooling purposes from the North Branch near Amcelle, and approximately 3.0 mgd of process water is obtained from the City of Cumberland.

The City of Cumberland, which serves the surrounding communities and industries, is the largest municipal user of water in the study area. Evitts Creek, which has a dependable yield of 18 mgd, is used as a source of water by the City of Cumberland. The average daily water use in 1966, exclusive of cooling water, was estimated to be about 12.5 mgd.

The majority of the remaining communities in the North Branch area have surface supplies.[4,5,6] In the South Branch Basin, the major source of water is from ground water.[9]

TABLE 2

PRESENT WATER USAGE

Area	Municipal Population	Municipal Use (mgd)	Industrial Process (mgd)	Industrial Cooling (mgd)	Total Use (mgd)
Luke-Keyser*	25,000	1.50	28.50	44.00**	74.00
Cumberland	54,000	5.55	7.00	58.00	70.55
Petersburg	2,000	0.17	0.23	0.00	0.40
Moorefield	1,400	0.25	0.33	0.00	0.58
Romney	2,200	0.17	0.00	0.00	0.17
Total	84,000	7.64	36.07	102.00	145.70

* Includes Frostburg Area.

** Includes about 15.0 mgd of recirculated cooling water from the West Virginia Pulp and Paper Company.

VI. PRESENT WASTE WATER LOADS

As presented in Table 3, the major waste water loads are from industrial sources in the Luke-Keyser and Cumberland Area. Of the 83,700 pounds of five-day BOD produced daily before treatment, about 84 percent is from industrial sources, with the remainder from municipalities.

TABLE 3

PRESENT WASTE LOADS

Area	Municipal Population Served	Municipal Volume (mgd)	Municipal #BOD/day* (5-day)	Industrial*** Volume (mgd)	Industrial*** #BOD/day* (5-day)
Luke-Keyser**	15,000	1.20	2,500	28.50	55,000
Cumberland	45,000	6.00	9,500	6.00	13,000
Petersburg	2,200	0.34	400	0.20	900
Moorefield	1,500	0.17	250	0.15	1,700
Romney	2,200	0.30	500	0.00	0

* Before treatment.

** Includes Frostburg Municipal Service Area.

*** Industrial values do not include waste loads to municipal systems nor cooling water volumes.

VII. FLOW ANALYSIS

Listed below are the minimum flow data for the water service areas investigated in this study.

TABLE 4

FLOW ANALYSIS

Area	Stream	Min. 7-day 25-yr. recur. Interval (cfs)	Min. 7-day 10-yr. recur. Interval (cfs)
Luke-Keyser	North Branch	93**	93**
Cumberland	North Branch	112**	112**
Petersburg	South Branch	32	56
Moorefield	South Branch	37	64
Romney	South Branch	44	76

** Corrected for regulation by existing Savage River Reservoir and Stony Creek Reservoir.

The minimum flow values for Luke-Keyser and Cumberland Areas will be increased by about 212 cfs when the Bloomington Reservoir Project is completed.[1]

VIII. PRESENT WATER QUALITY

The water quality in the North Branch of the Potomac River above the proposed Bloomington Dam site is characterized by low pH values (often less than 4.0), DO values near saturation, and low BOD values (often around 1.0 mg/l). See Table 5. Mine drainage in the upper North Branch area has a detrimental effect on the aquatic life, and fishing in these waters is virtually non-existent.

Water quality in the North Branch from Luke to the confluence with the South Branch is degraded by organic and mineral pollutants. The major sources of pollution in this study area are the West Virginia Pulp and Paper Company, the Celanese Corporation, and the City of Cumberland. Water quality sampling results for the North Branch are shown in Tables 6, 7, and 8.

The quality of the North Branch just above the confluence with the South Branch improves significantly. BOD values of about 2.0 mg/l, DO concentrations of 6.0 mg/l, and coliform counts of 2,300 per 100 ml typify the water quality near the confluence.

TABLE 5

SUMMARY OF ANALYSES OF WATER QUALITY DATA

North Branch Potomac River at Luke - River Mile 338.2
Critical Concentrations (January 1962-February 1965)

Item	Units	Critical Month	Mean	Number Observations for Critical Month
DO	mg/l	July	9.0	61
Temperature	°C	July	19.6	61
BOD_5	mg/l	July	4.5*	61
pH	---	August	4.7	65
Color	Platinum	July	7	61
Turbidity	Jackson Candle	March	45.1	65
Total Alkalinity	mg/l	May	4.0	65
Hardness	mg/l	July	83.7	61
Total Dissolved Solids	mg/l	July	217	61
Suspended Solids	mg/l	March	47	65

* Geometric

TABLE 6

SUMMARY OF ANALYSES OF WATER QUALITY DATA

North Branch Potomac River at Keyser - River Mile 331.0
Critical Concentrations (January 1962-February 1965)

Item	Units	Critical Month	Mean	Number Observations for Critical Month
DO	mg/l	August	6.8	65**
Temperature	°C	July	24.0	41
BOD_5	mg/l	December	21.2*	46
pH	---	September	8.2	60
Color	Platinum	August	118	64
Turbidity	Jackson Candle	October	115.7	68
Total Alkalinity	mg/l	April	13.8	57
Hardness	mg/l	October	210	68
Total Dissolved Solids	mg/l	October	638	68
Suspended Solids	mg/l	September	154	56

* Geometric

** Two years only

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DEVELOPMENT OF WATER RESOURCES IN APPALACHIA. VOLUME 19. APPEND--ETC(U)
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TABLE 7

WATER QUALITY DATA

North Branch Potomac River
Below Amcelle-River Mile 312.5

August 1966 - Chesapeake Field Station

Sample Taken Date	Time	Temp °C	pH	DO (mg/l)	BOD (mg/l)
8-1	1740	32	7.1	0	----
8-2	0930	28	7.0	0	26.9
8-2	1405	28	---	0.1	34.3
8-2	1930	28.5	7.0	0.1	25.2
8-3	0045	25.5	7.0	0.0	21.9
8-3	0535	26	6.6	0.1	18.8
8-3	1010	28	---	0.4	22.8
8-3	1700	31	7.1	0.4	7.4
8-3	2010	28	---	0.1	24.1
8-4	0130	27	6.8	0.6	20.2
8-4	0600	28	7.4	1.1	20.5
8-4	1105	27	7.8	0.0	17.9
8-4	1615	27	7.0	0.5	23.2
8-4	2035	27	7.2	0.1	28.0
8-5	0920	25	7.4	0.0	20.2
8-5	1145	27.5	---	0.2	21.8
8-5	1655	32	6.0	0.2	24.0
8-5	2200	28.5	7.1	0.3	23.1

TABLE 8

WATER QUALITY DATA

North Branch Potomac River
Below Cumberland-River Mile 296.7

August 1966 - Chesapeake Field Station

Sample Taken		Temp		DO	BOD
Date	Time	°C	pH	(mg/1)	(mg/1)
8-1	1515	26.5	8.0	7.5	9.34
8-2	0720	24	6.8	2.6	9.3
8-2	1210	25	5.9	4.2	4.4
8-2	1755	24.5	5.0	4.3	2.7
8-2	2235	23	5.2	3.3	4.1
8-3	0345	23	7.0	2.9	1.5
8-3	0830	23	---	2.7	---
8-3	1440	26	4.0	4.1	3.0
8-3	1820	27	---	4.2	2.7
8-3	2325	23.5	7.0	3.3	1.9
8-4	0425	24	6.6	2.6	4.1
8-4	1025	24	7.1	2.7	9.3
8-4	1430	24.5	7.2	3.5	2.3
8-4	1915	24	6.6	7.6	4.7
8-5	0030	24	6.5	2.9	19.0
8-5	0520	22.5	8.2	1.8	5.9
8-5	1025	23.5	7.0	1.9	10.3
8-5	1525	25.5	6.0	3.6	7.9
8-5	2035	25	6.5	4.7	7.2
8-6	0125	23	---	3.4	

The South Branch of the Potomac River, one of the least polluted streams in the Potomac River Basin, receives small amounts of treated municipal sewage effluent from Petersburg, Moorefield, and Romney, all of which provide secondary treatment. At the confluence with the North Branch, the water is of good quality, with DO values near saturation, BOD values less than 3.0 mg/l, and coliform counts less than 2,000 per 100 ml.

In the main stem of the Potomac River within the study area, there are no major municipal or industrial discharges. The quality is slightly degraded near the confluence of the North Branch and the South Branch as a result of the pollution loads discharged in the Luke and Cumberland Area. In the main, the quality is greatly improved because of dilution by higher quality water contributed by the South Branch and the natural assimilative capacity of the stream itself.

IX. POPULATION AND ECONOMY

The combined population of the major municipal service areas in the Region was about 77,000 in 1960. According to Office of Business Economics and Corps of Engineers' data, the combined population is projected to increase by 15 percent, 54 percent, and 110 percent by the years 1980, 2000, and 2020, respectively (see Table 9).

The projected productivity of the major water-using industries in the Region are given in Table 10. The two industries that are projected to have the most impact on future water needs are the West Virginia Pulp and Paper Company at Luke and the Celanese Corporation at Amcelle; both are located in the North Branch Sub-Basin.

TABLE 9

PROJECTED POPULATION

South Branch Potomac River

Area	1960	1980	2000	2020
Petersburg	3,351	4,300	6,400	9,700
Romney	2,987	3,600	5,100	7,300
Moorefield	1,534	2,400	4,500	8,900

North Branch Potomac River

Area	1960	1980	2000	2020
Cumberland-Cresaptown-LaVale	43,479	51,000	68,000	92,000
Keyser	6,192	7,200	9,500	12,800
Piedmont	2,871	2,500	3,000	3,300
Westernport-Luke	5,231	5,700	7,200	9,100
Kitzmillerville	535	400	300	300
Frostburg	9,216	10,700	13,900	18,600
Ridgely	1,229	1,100	1,100	1,100
Bayard	484	400	400	400
TOTAL	77,109	89,300	119,900	163,200

TABLE 10

PROJECTED INDICES OF PRODUCTION*

South Branch Potomac River

SIC**	Industry	1980	2000	2020
3111	Petersburg Tanning Co., Petersburg (Division of Loewengart)	125	160	200
2015	Pierce Pre-Cooked Foods, Moorefield	210	475	740
2013	Rockingham Poultry Co., Moorefield	210	475	740

North Branch Potomac River

SIC**	Industry	1980	2000	2020
1999	Alleghany Ballistics, Keyser, W. Va.	250	325	400
2281	Amcelle-Celanese, Amcelle, Md.	270	420	590
2621	West Virginia Pulp and Paper Co., Luke, Md.	265	450	740
3011	Kelly-Springfield Tire, Cumberland, Md.	280	450	700

* A base of 100 was used for 1960.

** Standard Industrial Classification.

X. WATER SUPPLY NEEDS

Municipal water supply requirements were determined by using the water service area populations previously described and applying future per capita water consumption rates recommended by the U. S. Senate Select Committee on National Water Resources[8] (see Figure 2).

Industrial water supply requirements are estimated on the basis of projected product output for the major types of water-using industries. Technological changes in industrial processes, as well as unexpected additional industrial development in the area, could significantly alter the industrial water supply needs presented.

Due to proposed stringent standards for thermal discharges by the State of Maryland, and possible use of cooling towers, cooling water needs were not included in the projection.

Using the projected economic and demographic data developed in the preceding Section, the municipal and industrial water supply needs given in Tables 11, 12, and 13 were computed. These tables show that in the South Branch water service area, the present stream flow will be adequate to meet anticipated water supply demands.

Although stream flows appear to be adequate to meet the water supply needs in the North Branch water service areas, the Bloomington project will drastically upset the equiponderance of alkalinity and acidity contribution relationships, especially during the low flow months. Assuming the quality of the increased dependable flow is similar to existing water quality, the effect of mine drainage may extend as far downstream as Cumberland, Maryland. Further, the West Virginia Pulp and Paper Company installed a lime recovery unit in 1966, thereby reducing significantly a needed neutralizing capacity. If the mine drainage is not reduced, the water quality in the North Branch from Luke to Cumberland may not be suitable for industrial or municipal water supply without costly additional water treatment.

There have been proposals to develop a water supply system for the North Branch area using the Savage as a source of supply because of its better quality.[4,6]

TABLE 11

PROJECTED MUNICIPAL WATER NEEDS

Area	1980 Demand Population Served	1980 Demand gcd	1980 Demand Usage (mgd)	2000 Demand Population Served	2000 Demand gcd	2000 Demand Usage (mgd)	2020 Demand Population Served	2020 Demand gcd	2020 Demand Usage (mgd)
Luke-Keyser*	27,000	120	3.25	37,000	150	5.50	46,000	150	6.90
Cumberland	64,000	120	7.70	85,000	150	12.75	114,000	150	17.20
Petersburg	4,300	120	0.51	6,400	150	0.95	9,700	150	1.45
Moorefield	2,400	120	0.29	4,500	150	0.67	8,900	150	1.33
Romney	3,600	120	0.43	5,100	150	0.76	7,300	150	1.10

* Includes Frostburg Municipal Service Area.

TABLE 12

PROJECTED INDUSTRIAL WATER NEEDS

(Excluding Cooling Water)

	1980				2000				2020			
Area	Water Use Index***	Linear Proj. mgd	Atten. Factor**	Proj. Use mgd	Water Use Index***	Linear Proj. mgd	Atten. Factor**	Proj. Use mgd	Water Use Index***	Linear Proj. mgd	Atten. Factor**	Proj. Use mgd
Luke-Keyser	1.23	35.0	0.80	28.0	2.10	57.0	0.70	40.0	3.45	95.0	0.60	56.0
Cumberland	2.70	19.0	0.80	15.0	4.20	29.0	0.70	21.0	6.00	41.0	0.60	25.0
Petersburg	1.25	0.3	1.00	0.3	1.50	0.4	1.00	0.4	2.00	0.5	1.00	0.5
Moorefield	1.50	0.5	1.00	0.5	3.00	1.0	1.00	1.0	4.20	1.4	1.00	1.4
Romney	----	----	----	0.1*	----	----	----	0.2*	----	----	----	0.2*

* Estimated values.

** Attenuation factors based on studies by FWPCA, Water Resources Section, CB-SRBP, Charlottesville, Virginia (estimated decrease is due to technological changes).

*** Water use index is a weighted value of the individually projected industries for a given service area. For Luke-Keyser area the index is based on the 1966 productivity and water use data due to great change in production capabilities at the West Virginia Pulp and Paper Company.

TABLE 13

SUMMARY OF FUTURE WATER NEEDS
(Excluding Cooling Water)

South Branch Potomac River

Area	Min. 7-Day 25-Yr. Recur. Interval mgd	1980 Proj. Need mgd	1980 Proj. Deficit mgd	2000 Proj. Need mgd	2000 Proj. Deficit mgd	2020 Proj. Need mgd	2020 Proj. Deficit mgd
Petersburg	32	0.81	none*	1.35	none	1.90	none
Moorefield	37	0.79	none	1.67	none	2.80	none
Romney	44	0.44	none	0.96	none	1.30	none

North Branch Potomac River

Area	Min. 7-Day 25-Yr. Recur. Interval mgd	1980 Proj. Need mgd	1980 Proj. Deficit mgd	2000 Proj. Need mgd	2000 Proj. Deficit mgd	2020 Proj. Need mgd	2020 Proj. Deficit mgd
Luke-Keyser	93**	31.3	none*	45.5	none	62.9	none
Cumberland	112**	22.0	none	34.0	none	44.0	none

* Projected use is much less than minimum 1-day low flow with a recurring interval of once in 30 years, thus, there is no apparent additional need.

** Corrected for regulation by existing Savage River Reservoir and Stony Creek Reservoir.

XI. WATER QUALITY CONTROL NEEDS

The projected waste loads for the municipal service areas are based upon the projected populations shown in Table 9 with a contributing per capita waste load of 0.17 pounds of 5-day BOD per day. Future industrial waste loads are based on the industrial water needs given in Table 12. The characteristics of the industrial wastes were assumed to remain constant. Tables 14 and 15 show the projected municipal and industrial waste loadings.

The stream flow necessary to assimilate the projected waste loads without depleting the dissolved oxygen (DO) below 5.0 mg/l were determined using Thomas' step version of the Streeter-Phelps formulation of the oxygen-sag equation. A mathematical model relating temperature, dissolved oxygen, biochemical oxygen demand, and stream flow established for the Potomac River Basin was used in this investigation.

The flow requirements are based on mean monthly high temperatures which will be equalled or exceeded 25 percent of the time. Also incorporated in the analysis are the current cooling water needs and effects of the heated discharges.

Three levels of waste water treatment were investigated and are listed below:

Level I - 85 percent removal of 5-day BOD
(conventional secondary treatment)

Level II - 90 percent removal of 5-day BOD

Level III - 95 percent removal of 5-day BOD

Level I is considered to be a minimum level for the purpose of using flow augmentation as an alternative to additional waste water treatment.

The annual expenditures required to provide either Level II or III, over and above Level I, were obtained from a study by Frankel.[7] The cost of the additional levels of treatment are the total amount of cost for operation, maintenance, and amortization at four and one-half percent interest charges over 20 years. The Engineering News Record Cost Index or Department of the Interior STP Index applicable to the given costs is 1020 (1966 average).

TABLE 14

PROJECTED MUNICIPAL WASTE LOADS

Area	1980			2000			2020		
	Population Served	Volume mgd	#BOD/ Day**	Population Served	Volume mgd	#BOD/ Day**	Population Served	Volume mgd	#BOD/ Day**
Luke-Keyser	16,000	1.93	2,700	20,000	3.00	3,400	25,600	3.85	4,300
Cumberland*	61,400	7.35	10,700	103,000	15.40	17,500	121,600	18.20	20,600
Petersburg	4,300	0.51	700	6,400	0.95	1,100	8,700	1.45	1,500
Moorefield	2,400	0.29	400	4,500	0.67	800	8,900	1.33	1,500
Romney	3,600	0.43	600	6,100	0.76	900	7,300	1.10	1,200

* Includes Frostburg Municipal Service Area.

** Loadings based on 0.17 pounds of 5-day BOD/capita/day.

TABLE 15

PROJECTED INDUSTRIAL WASTE LOADS

Area	1980		2000		2020	
	Volume mgd	#BOD/Day*	Volume mgd	#BOD/Day*	Volume mgd	#BOD/Day*
Luke-Keyser	28.0	55,000	40.0	80,000	56.0	110,000
Cumberland	15.0	28,000	22.0	41,000	25.0	46,000
Petersburg	0.3	1,100	0.4	1,350	0.5	1,800
Moorefield	0.5	2,800	1.0	5,100	1.4	7,200
Romney	0.1	100	0.2	200	0.2	200

* Before treatment.

North Branch Potomac River

Water quality in the North Branch is greatly affected by a low-level dam above the City of Cumberland. Changes in stream velocity and depth drastically increase the amount of BOD exerted and reduce the reaeration capacity in the pool above the dam.

Since there are presently very low DO values in the area above the dam, the projected growth of industrial productivity will cause an even greater deterioration in water quality in this reach. Two possible methods of avoiding high future waste water treatment requirements or large volumes of reservoir storage for quality control are: (1) the transportation of all waste water in this reach below the dam, or (2) the removal of the dam.

In defining the water quality control needs for the North Branch, all projected increases in waste water in the immediate area above the dam were assumed discharging to the Cumberland sewer system. This assumption is within the framework of the industrial and demographic projections, communications with Celanese Corporations, and the proposed Waste Acceptance Service of the State of Maryland. Due to the time-dependent nature of waste loads and location of the proposed reservoir projects in the North Branch Watershed, the flow requirements were determined for the reach of stream from Luke, Maryland, to the confluence with the South Branch.

Table 16 presents the flow requirements for the three levels of treatment for the years 1980, 2000, and 2020. Also given in Table 16 are costs of increasing the waste treatment level above the conventional 85 percent removal of the 5-day BOD.

From data presented in Table 16, it can be seen that in the last seven months of the year, June through December, some flow regulation above the current minimal requirement of 93 cfs will be necessary even at the higher treatment levels. The tabulation of data indicates that a minimum base flow is needed primarily to provide dilution water due to a large ratio of low DO waste water production to stream flow.

Upon completion of the Bloomington Reservoir Project, the increased dependable flow in the North Branch at Luke was determined to be about 212 cfs.[1] Added to current 93 cfs requirements, the total dependable flow at Luke will be about 305 cfs. This increase in flow will be more than adequate to meet the water quality control requirements for biologically degradable waste waters (see Table 16). Therefore, no additional flow augmentation storage is required in the North Branch Basin for water quality control.

TABLE 16

WATER QUALITY CONTROL FLOW REQUIREMENTS FOR 5.0 mg/l OF DO

North Branch of Potomac River from
Luke, Maryland, to Confluence with South Branch

Design Year	Level of Treatment	Annual Cost of Increased Treatment	Flow Requirements in cfs Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	I (85%)	base	93	93	93	93	93	120	110	110	100	93	93	93
	II (90%)	$61,000	93	93	93	93	93	95	100	100	95	93	93	93
	III (95%)	$420,000	93	93	93	93	93	93	93	93	93	93	93	93
2000	I (85%)	base	93	93	93	93	93	110	115	115	110	93	93	93
	II (90%)	$90,000	93	93	93	93	93	95	100	100	95	93	93	93
	III (95%)	$585,000	93	93	93	93	93	93	93	93	93	93	93	93
2020	I (85%)	base	93	93	93	93	93	120	140	140	115	93	93	93
	II (90%)	$105,000	93	93	93	93	93	100	110	110	100	93	93	93
	III (95%)	$690,000	93	93	93	93	93	93	95	95	93	93	93	93
Flow* (cfs)			260	320	820	450	320	100	93**	93**	93**	93**	93**	100
Design Temperature °C			5	5	8	15	20	25	27	27	23	16	10	5

* This is the mean monthly low flow value in cfs, based on a log normal probability distribution which occurs five percent of the time or less (1950-1966).

** Minimum flow maintained at Luke, Maryland, by Upper Potomac River Commission.

As indicated in the Section on water supply needs, the water quality may be seriously affected during the low flow months by the Bloomington Reservoir Project. Field studies are currently being conducted by the Middle Atlantic Region in order to assess the effect of the reduction in alkaline discharges by West Virginia Pulp and Paper Company. These studies should be good indications as to the possible effect of the increased flow by the Bloomington Project.

South Branch and Upper Main Stem Potomac River

No present or projected need for reservoir storage for water quality control is anticipated in this area if all waste waters are given conventional secondary biological treatment.

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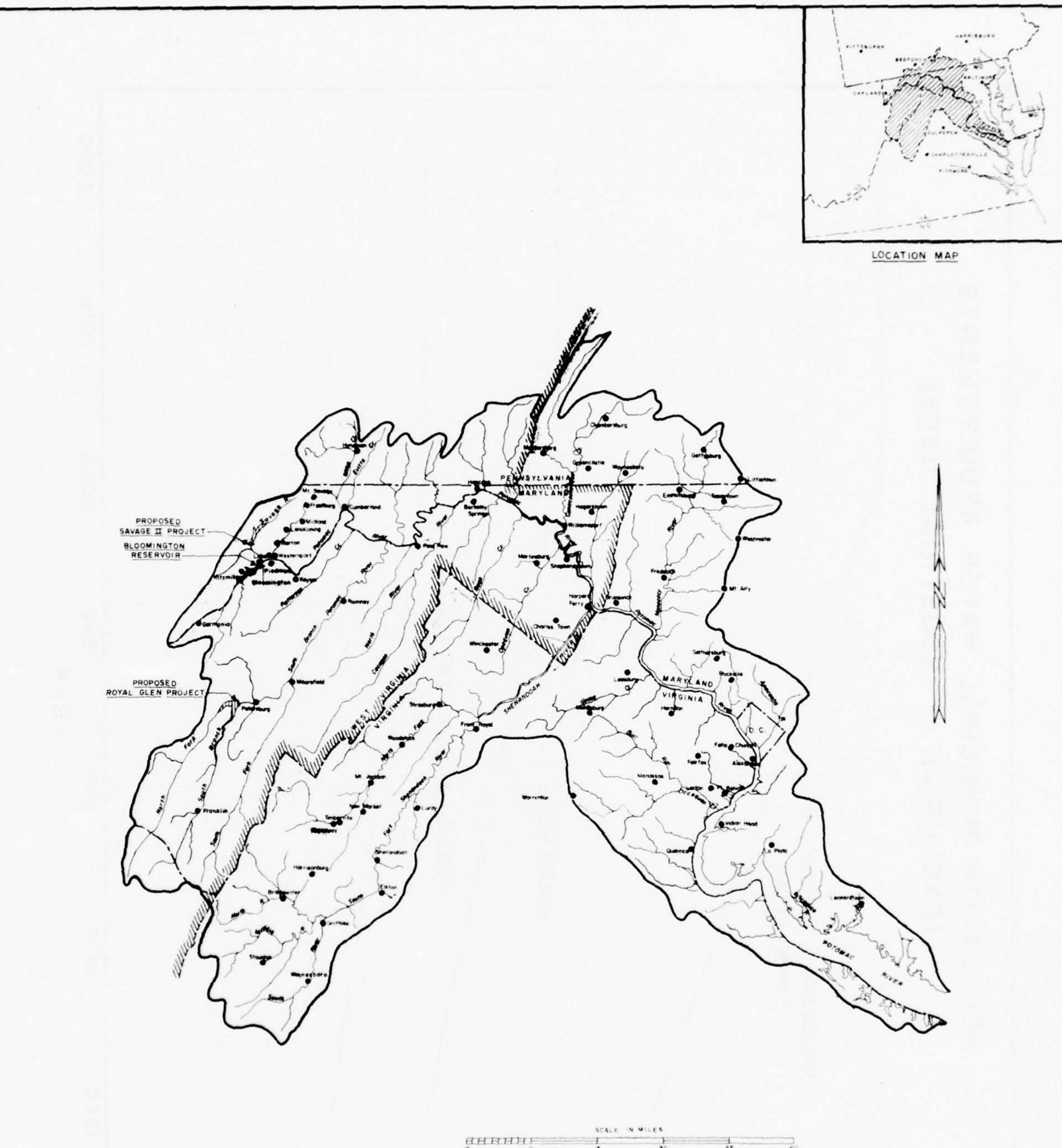

LEGEND:

INDICATES APPALACHIA REGION BOUNDARY

APPALACHIA PROGRAM
WATER SUPPLY & WATER QUALITY CONTROL STUDY

POTOMAC RIVER BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION CHARLOTTESVILLE, VA.

FIGURE 1

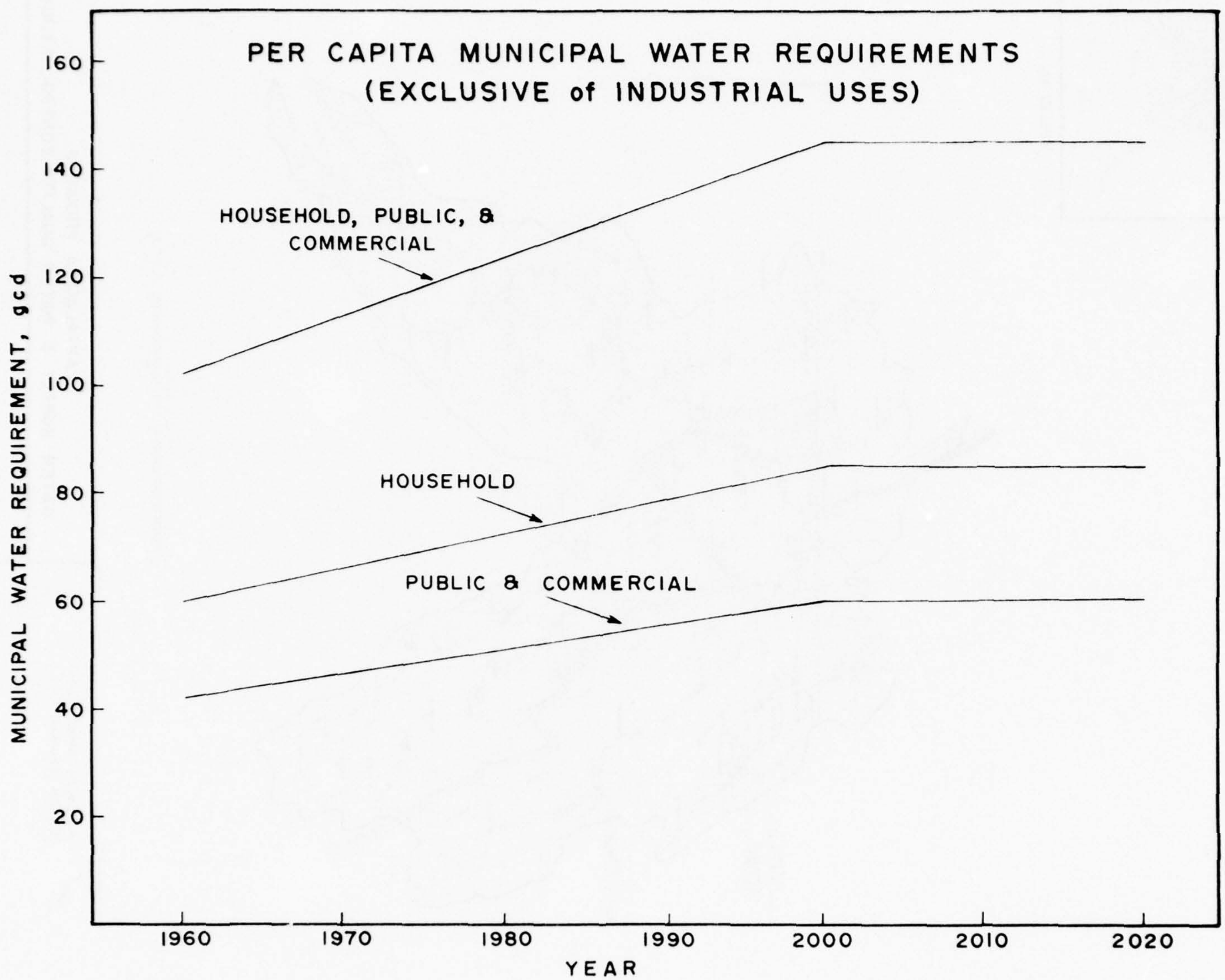
PER CAPITA MUNICIPAL WATER REQUIREMENTS
(EXCLUSIVE of INDUSTRIAL USES)
HOUSEHOLD, PUBLIC, &
COMMERCIAL
HOUSEHOLD
PUBLIC & COMMERCIAL
MUNICIPAL WATER REQUIREMENT, gcd
160
140
120
100
80
60
40
20
1960
1970
1980
1990
2000
2010
2020
YEAR

FIGURE 2

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

CLINCHFIELD RESERVOIR

Broad River, North and South Carolina

Prepared for

U. S. Department of the Army
Corps of Engineers - Appalachia Study
U. S. Army Engineer District
Charleston, South Carolina

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Middle Atlantic Region
Charlottesville, Virginia

October 1967

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I. REQUEST AND AUTHORITY

In a letter dated June 11, 1965, the U. S. Army Engineer District, Charleston, Corps of Engineers, Charleston, South Carolina, requested the Regional Program Director, Water Supply and Pollution Control Program, U. S. Public Health Service, Charlottesville, Virginia[1], to prepare an estimate of present and projected needs for water supply and water quality control in the Santee River Basin that could be provided by the proposed Clinchfield Reservoir on the Broad River in Rutherford County, North Carolina.

This report was prepared under the authority of the Appalachian Regional Development Act of 1965, P.L. 89-4, Section 206C.

II. PURPOSE AND SCOPE

The purpose of this study was to determine the need for and value of water supply and water quality control storage in the proposed Clinchfield Reservoir. Water supply needs were determined by identifying present water uses and estimating future uses based on economic data supplied by the Charleston District Corps of Engineers. Stream flow requirements to meet water quality objectives were determined utilizing computerized mathematical stream models. Benefits attributable to water supply and water quality control were calculated.

The scope of this study entailed the evaluation of water supply needs and effects of waste discharges on the receiving streams from the junction of the Wateree and Congaree Rivers upstream to the proposed Clinchfield dam site. (See Figure 1)

Future needs for the study area, which consists of Cleveland, Polk, and Rutherford Counties in North Carolina and Calhoun, Cherokee, Chester, Fairfield, Greenville, Lexington, Newberry, Richland, Spartanburg, Union and York Counties in South Carolina, have been estimated for a 50-year period.

The study area was divided into two portions. The upper portion consists of the Appalachian Counties of Polk and Rutherford in North Carolina; Greenville, Spartanburg and Cherokee in South Carolina; and the non-Appalachian County of Cleveland, North Carolina. The

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[1] Certain water pollution control functions of this organization were reorganized under the Federal Water Pollution Control Administration which was subsequently transferred to the Department of the Interior on May 10, 1966.

lower portion consists of Calhoun, Chester, Fairfield, Lexington, Newberry, Richland, Union and York. The time period for evaluations of the areas begins in 1970 and ends in 2020, and has selected intermediate points for evaluations of 1980 and 2000.

The proposed Clinchfield Reservoir, located in the headwaters of the Broad River near Cliffside, North Carolina, has a drainage area of 571 square miles. The Broad River has its headwaters on the eastern slope of the Blue Ridge Mountains at an elevation of approximately 4,000 feet and flows in a southeasterly direction about 166 miles, where it joins the Saluda River to form the Congaree River at Columbia, South Carolina. The major streams tributary to the Broad River are the Green, Second Broad, First Broad, Pacolet, Tyger and Enoree Rivers.

Mean discharges range from 169 cubic feet per second (cfs) on the Broad at Chimney Rock, North Carolina (U.S.G.S. Gage No. 1485, 31 years of record), to 8,708 cfs on the Congaree at Columbia, South Carolina (U.S.G.S. Gage No. 1695, 25 years of record), just south of the junction of the Broad and Saluda Rivers. The seven-day consecutive low flow with a recurrence interval of once in ten years at U.S.G.S. Gage No. 1695 is approximately 1,600 cfs.

III. SUMMARY OF FINDINGS

Estimated projections of economic and demographic growth indicate that the principal future increases in water supply demand will be oriented to the Greenville-Spartanburg and the Columbia Metropolitan complexes. A modest increase in water demand may be expected in the Cherokee-Cleveland-York County subarea. That portion of the Broad River, flowing through the rural piedmont counties of Chester, Union, Newberry and Fairfield is not expected to experience significant increases in demand for water.

Existing water resources in the portion of the Broad River Basin below the Broad-Enoree River junction will provide sufficient water to meet future needs beyond 2020. The upper portion of the basin in the Appalachia area and bordering counties have a need for additional water sources due to the relatively small sizes of the streams in the vicinity.

Water supply sufficient to meet the 2020 need of 140 million gallons per day required in the upper portion of the basin can be met by providing 21,300 acre-feet of storage in the Clinchfield Reservoir. The value of annual benefits derived by meeting these needs is $494,500, which is based on providing single-purpose reservoirs on the North Pacolet River and North Carolina streams tributary to the Broad River.

Due to the relatively small size of receiving streams and the estimated future waste loadings in the upper portion of the basin in South Carolina, the Pacolet, Tyger, and Enoree Rivers are expected to experience water quality problems between 1980 and 2000, based on 85 percent removal as measured by Biochemical Oxygen Demand (BOD). The Pacolet River is the only stream that will exert an influence of any consequence on the water quality in the Broad River by 2020.

Waters of the upper portion of the Broad River Basin are classified to protect such beneficial uses as recreation, water supply, and fish and wildlife. Water quality can be maintained in the Pacolet and Broad Rivers by any one of three methods: (1) advanced waste treatment of all the wastes in the Spartanburg area, (2) quality control releases from a reservoir located on the North Pacolet River near Fingerville, South Carolina, and (3) piping the wastes from the Spartanburg area to the Broad River and providing quality releases from the proposed Clinchfield Reservoir on the Broad River.

Flow augmentation from a single-purpose reservoir constructed on the North Pacolet River would be the least costly water quality control method for protecting aesthetics and fishing in the Pacolet River. The value of annual benefits derived from maintaining these beneficial stream uses is estimated to be $526,000. All benefits are based on a 50-year amortization of capital costs at an interest rate of three and one-eighth percent plus estimated annual operation and maintenance costs.

Studies of water quality control needs for the Tyger and Enoree Rivers are desirable. Protection of beneficial stream uses necessitates that water quality control planning be initiated soon, as projected waste loads indicate a need for quality control between 1980 and 2000.

IV. PRESENT WATER USE

Basic data collected for the study area indicate that the total average present water use is approximately 95 million gallons per day (mgd). Present water use is met almost entirely from surface water supplies. Individual systems and some industries and municipalities utilize groundwater in conjunction with surface water as a source of supply. However, groundwater yields are not of sufficient magnitude to be relied on as a source for large water users.

Table 1 shows the 1965 daily capacity and average daily water use of existing sources of supply being utilized by the major municipalities within the counties involved in the study area. The values

shown include both municipal and industrial water uses; however, many industries within the basin operate their own water systems.

TABLE 1

Municipal Water Supply Capacity and Average Present Water Use for Municipalities Using Over One Million Gallons Per Day, by Counties, Broad River Basin, North and South Carolina*

Counties	Source of Present Water Supply	Million Gallons per Day: Estimated Capacity of Water Supply Source	Million Gallons per Day: Average Present Use
Cleveland, N. C.			
Shelby	First Broad River	29	3.4
Cherokee, S. C.			
Gaffney	Cherokee & Little Cherokee Creek	14	3.2
Greenville, S. C.			
Greenville	Saluda River	60	23.0
Greer	South Tyger River	10	2.0
Richland, S. C.			
Columbia	Broad River	--	19.3
Spartanburg, S. C.			
Spartanburg	South Pacolet	40	18.4
Union, S. C.			
Union	Broad River	--	3.0
York, S. C.			
York	Catawba River	20	3.4

* North Carolina Department of Water and Air Resources, Broad River Survey, 1962. South Carolina State Department of Health Records, 1965. Information from municipal water supervisors, 1966.

V. PRESENT WATER QUALITY

The Broad River is characteristically a stream of good quality water. The water within the Broad has a near neutral hydrogen ion (pH) concentration and is low in chlorides and dissolved solids. Water quality data obtained by the States of North and South Carolina, and the Federal Water Pollution Control Administration indicate that the 5-day 20° centigrade biochemical oxygen demand is normally below 2 to 3 milligrams per liter (mg/l), indicating low levels of organic substances. The dissolved oxygen levels are consistently in excess of 7.0 mg/l throughout the Broad River.

Sampling conducted by the Federal Water Pollution Control Administration in August and September of 1966 indicates that some streams tributary to the Broad River experience very low dissolved oxygen levels and high BOD. Degraded water quality is a direct result of tributary streams receiving large amounts of municipal and industrial wastes in relation to stream flow and assimilative capacity.

Due to the variability of underlying rock strata within the Broad Basin ground water chemical characteristics vary considerably; but, generally, these waters are of good quality. Table 2 summarizes some of the chemical quality parameters for both surface and ground water in the Broad Basin.

Presently there are approximately 305 municipal and industrial waste sources in the Broad River Basin, approximately 238 of which provide secondary treatment, 44 primary treatment, and 23 no treatment. The total waste load generated is approximately 86 mgd with a population equivalent (P.E.) of 1,930,000 before treatment. There are approximately 274 waste sources in the upper portion of the basin of which 216 provide secondary treatment, 41 primary, and 17 no treatment. The total waste load generated is approximately 56 mgd with a P.E. of 1,300,000.

TABLE 2

BROAD RIVER BASIN
Miscellaneous Analyses of Stream and Ground Water

Location	Discharge (cfs)	Chloride (cl)	Nitrate (NO_3)	Dissolved Solids	Hardness as $CaCO_3$	pH
Surface Water						
Second Broad River at Cliffside, N.C.	400	3.8	0.1	52	10	6.5
First Broad River near Casar, N.C.	29	1.5	0.5	34	12	7.1
Broad River near Gaffney, S.C.	1,260	6.2	0.7	49	14	6.8
Pacolet River near Clifton, S.C.	231	2.5	0.4	39	14	6.7
Tyger River near Delta, S.C.	716	6.8	1.5	90	19	6.9
Enoree River near Enoree, S.C.	395	3.3	2.2	50	12	6.8
Broad River at Richtex, S.C.	7,460	3.9	0.2	43	14	6.4
Ground Water						
Cherokee County, Blacksburg		2.5	0.3	124	92	7.7
Cherokee County, 5 mi. N.E. of Gaffney		2.0	0.1	52	32	6.9
Greenville County, Fountain Inn		12.0	21.0	72	19	5.6
Spartanburg County, Cowpens Well #6		2.0	0.8	38	15	6.0
Spartanburg County, Cowpens Well #4		2.0	0.5	100	41	6.8

VI. THE ECONOMY

Unless otherwise stated, all data used in this economic analysis of the five-county study area are provided by the U. S. Army Corps of Engineers, Office of Appalachian Studies. Data for the remainder of the Broad River Basin was obtained from "Estimates of Future Economic Growth for Water Resource Planning, Broad River Basin, North and South Carolina" which was prepared under contract by Clemson University, Clemson, South Carolina.

Income

In 1960 the mean per capita income in the five-county Appalachia area of Polk and Rutherford, North Carolina, and Cherokee, Greenville, and Spartanburg, South Carolina, was $1,377, as compared to $1,379 for the State of South Carolina, $1,560 for the State of North Carolina, and $2,215 in the entire United States.[1]

Manufacturing Output

The following table lists only major water users in the five-county study area and their projected indexes of output through 2020 as computed from employment projections and gross output per employee projections.

Manufacturing Output

County	SIC	Industry	1960 Output ($1,000)	Index 1960=100 1980	2000	2020
Polk	20	Food Products	$ 156*	300	600	900
	22	Textile Products	5,007*	200	400	600
Rutherford	20	Food Products	1,186*	300	600	900
	22	Textile Products	29,907*	150	200	400
Cherokee	20	Food Products	782*	300	600	900
	22	Textile Products	18,322	150	200	400
	28	Chemical Products	3,908	300	700	1,000
Greenville	20	Food Products	15,014	300	600	900
	22	Textile Products	112,150	150	200	300
	26	Paper Products	7,799	200	300	400
Spartanburg	20	Food Products	7,406	300	600	900
	22	Textile Products	103,938	300	600	1,000
	26	Paper Products	4,200*	200	400	800
	28	Chemical Products	5,584*	300	700	1,000

* OBE data used because Census of Manufacturers data not available.

1 County and City Data Book (1962)

Population

Below is a table showing 1960 water service area population in the study area and projections of future growth through 2020.

Broad River Basin Water Service Areas

	1960	1980	2000	2020
Calhoun County	12,256	8,210	14,830	23,040
Cherokee County	35,205	52,009	85,641	134,586
Chester County	30,888	28,180	29,800	36,600
Cleveland County	66,048	80,040	120,870	151,890
Fairfield County	20,713	20,620	22,350	35,950
Greenville County *	209,776	309,576	510,063	801,578
Lexington County	60,726	132,440	209,000	378,320
Newberry County	29,416	26,690	42,040	49,500
Polk County	11,395	16,865	27,771	43,643
Richland County *	200,102	310,190	438,510	682,000
Rutherford County	45,091	58,500	96,700	142,900
Spartanburg County *	156,830	231,611	381,384	599,356
Union County	30,015	29,540	41,290	49,410
York County	78,760	113,030	166,540	242,920

* The Greenville-Spartanburg Metropolitan area is located in Greenville and Spartanburg Counties, and the Columbia Metropolitan area is located in Richland County.

By 2020, the population will almost quadruple, the area growth rate being 2.26 percent per year as compared to the national rate of 1.66 percent according to data provided by the Office of Business Economics. The percentage of population served will increase 105 percent by 2020.

VII. WATER SUPPLY NEEDS

Future estimated water supply needs have been determined based on area requirements rather than for individual municipalities utilizing economic data and projections. A listing of these future needs is given in Table 3.

Estimates indicate that the 2020 Spartanburg County needs are approximately 112 mgd, while the remainder of the upper portion of the basin is expected to have projected needs of 28 mgd. Water supply needs in the upper portion of the basin will exceed the estimated capacity of the present water sources between 1980 and 2000.

TABLE 3

Water Supply Requirements
Million Gallons per Day

Area Requirements**	Present	1980	2000	2020
A*	2.7	4.7	7.2	13.7
B*	2.2	3.9	5.8	7.2
C*	3.2	4.7	6.4	10.9
D	1.5	4.3	6.7	8.1
E*	2.0	6.1	9.4	11.8
F*	2.8	8.7	15.1	26.0
G*	4.0	8.8	12.2	15.8
H	8.4	13.0	17.8	25.0
I*	14.1	16.8	22.4	41.9
J*	1.5	2.0	4.1	5.4
K*	2.5	3.0	4.2	7.4
L	6.3	11.0	16.3	22.7
M	1.7	5.0	8.0	11.6
N	1.5	3.1	4.4	6.1
O	25.1	38.2	55.6	85.2

* Indicates those areas that could be readily served by the proposed Clinchfield Reservoir.

** See Figure 1 for locations.

In that portion of the Broad-Enoree River junction, existing water resources will provide sufficient water to meet future needs beyond 2020.

The Columbia-Cayce subarea is the largest complex in the lower portion of the basin. Water resources of the Broad and Saluda Rivers are sufficient to provide water supply in excess of estimated needs of approximately 85 mgd.

Estimated total water supply requirements that could be potentially supplied by the Clinchfield Reservoir are shown as follows:

Clinchfield Reservoir Area Water Supply Requirements

	1980	2000	2020
Area Supply Requirements (mgd)	61	84	140

Storage of 21,300 acre-feet of water supply at the Clinchfield Reservoir site will provide flow to meet the 2020 requirement of 140 mgd. This requirement can also be met by the storage of 61,500 acre-feet on the North Pacolet River and North Carolina streams tributary to the Broad River.

VIII. WATER QUALITY CONTROL NEEDS

Waters of the upper portions of the Broad River Basin are classified by the North Carolina Department of Water and Air Resources and the South Carolina Pollution Control Authority to protect such beneficial uses as recreation, water supply, fish and wildlife, and aesthetics.

Standard secondary treatment and disinfection of effluents will protect water supply and recreation uses. Secondary treatment of all wastes will also provide sufficient reduction of oxygen demanding wastes to meet stream dissolved oxygen standards as set by the States in all of the streams in the basin except the Pacolet River, Broad River, and upper portions of the Tyger and Enoree Rivers. Protection of fish and wildlife on these rivers requires the maintenance of a dissolved oxygen level of 4.0 mg/l.

Water quality flow values necessary to maintain a minimum dissolved oxygen concentration of 4 mg/l in the Pacolet and Broad Rivers have been developed utilizing computerized techniques. These flow values represent flow necessary to maintain acceptable conditions in the streams provided all wastes are collected and receive sufficient treatment to remove at least 85 percent of the waste load as measured by biochemical oxygen demand.

The required stream flow and associated year 2020 storage required for water quality control near Pacolet, South Carolina, to protect beneficial water uses in the Pacolet River are shown in Table 4. The proposed storage will provide sufficient water for flow regulation so there will be no more than a five percent chance in any given year that the dissolved oxygen will drop below 4.0 mg/l for periods exceeding 30 days. This will usually occur during the summer months and would not result in a total contravention of beneficial uses. For example, it is recognized that warm water fish will survive for extended periods at dissolved oxygen levels in the range of 3.0 mg/l.

TABLE 4

Required Stream Flow for Water Quality Control
Pacolet River near Pacolet

Month	Year 1980	Year 2000	Year 2020
January	25	112	285
February	25	105	270
March	50	165	365
April	110	285	540
May	205	405	720
June	280	505	880
July	335	570	980
August	310	550	905
September	235	450	780
October	155	340	610
November	90	265	505
December	50	180	375

Storage required in a reservoir at the Fingerville site to maintain 2020 flows--116,900 acre-feet.

The Pacolet River can also be protected by eliminating waste discharges to the Pacolet and transporting them to the Broad River for release. Treated wastes discharged to the Broad River necessitate the stream flow and associated year 2020 storage as shown in Table 5.

The stream flows shown in Tables 4 and 5 indicate required stream flow and are based on estimated waste loadings developed utilizing the economic projections in the Economy Section; therefore, they should not be interpreted as reservoir release schedules. Water quality releases should be made on the basis of stream needs as determined by the responsible water pollution control agency from data obtained through water quality monitors.

Because of poor water quality associated with thermal stratification, a multi-level outlet structure should be incorporated in the design of water quality control reservoirs to permit the release of water high in dissolved oxygen. The multi-level outlet will also provide for the passage of fish from the reservoir to the tailwaters. Stream monitoring equipment should be installed downstream to provide information to be used for determining reservoir releases and developing a water quality management program for the basin.

TABLE 5

Required Stream Flow for Water Quality Control
Broad River near Parr

(cfs)

Month	Year 1980	Year 2000	Year 2020
January	710	1150	1550
February	660	1100	1530
March	830	1290	1670
April	940	1460	1810
May	1000	1540	1910
June	1015	1570	1970
July	1050	1600	2000
August	1040	1590	1980
September	1010	1550	1930
October	970	1500	1870
November	920	1430	1800
December	860	1350	1700

Storage required in a reservoir at the Clinchfield site to maintain 2020 flows--48,300 acre-feet.

Projected water quality needs for the Tyger and Enoree Rivers indicate the need for further engineering studies of these streams.

IX. BENEFITS

Water Supply

Water supply needs for the upper portion of the Broad River Basin that could be met by constructing a single-purpose reservoir at the Clinchfield site or on the North Pacolet River near Fingerville, South Carolina and North Carolina tributaries were determined. These water supply needs can be met from the Clinchfield site by providing 21,300 acre-feet of storage. Due to the differences in drainage area and basin hydrology, a total storage of 61,500 acre-feet will be required on the North Pacolet and North Carolina tributaries to provide sufficient water supply. Water supply storage at the Clinchfield and Fingerville sites needed to supply the Spartanburg area, approximately 112 mgd in 2020, will have to be pumped to be available at the Spartanburg municipal reservoir on the South Pacolet River.

Presented below is a tabulation of the comparative costs of providing water supply from either the Clinchfield or Fingerville and North Carolina sites.

	Construction Site	Fingerville and N. C. Sites
Present worth storage costs	$7,650,000*	$9,920,000
Present worth pumping costs	8,135,000	2,500,000
TOTAL	$15,785,000	$12,420,000
Average annual costs	628,000	494,500

* The present worth of all costs at year 1970 has been determined and then amortized over a project life of 50 years at three and one-eighth percent to determine annual costs in this report.

The average annual cost of providing water supply from the Fingerville site is $133,500 less than the average annual cost of water supply in the Clinchfield site. The average annual cost of $494,500 is a measure of the value of benefits for the 140 mgd to be supplied to the upper portion of the Broad River Basin.

Water Quality Control

The value of water quality control benefits may be determined by assessing damages that would result in the absence of quality control beyond that of providing secondary treatment. Direct evaluation of all economic effects as a result of present or future water quality cannot be made due to lack of data on loss of recreational opportunities, aesthetics, fish and wildlife, and other beneficial uses; therefore, the value of benefits has been estimated to be equal to the least cost alternate for protecting the beneficial stream uses. The discharge of wastes from the Spartanburg area to the Pacolet River, based on projected waste loads, will degrade the stream and reduce beneficial water uses. The degradation of the stream during periods of low flow will extend from the point of waste discharge down the Pacolet and into the Broad River, a distance of approximately 30 miles.

The reduction of beneficial water uses associated with fishing and aesthetics can be prevented by any one of the three following methods:

1. Collect and treat all wastes in the Spartanburg area utilizing advanced waste treatment.

2. Flow regulation from a reservoir located on the North Pacolet River.

3. Collect all wastes in the Spartanburg area, treat and pipe the waste to the Broad River for discharge, in conjunction with flow regulation in the Broad River from a reservoir located at the Clinchfield site.

The first method indicated above, advanced waste treatment, would result in a present worth of $17,108,000. This sum of money, which includes capital and operation and maintenance costs, would result in an estimated average annual cost of $681,000.

The second method would require a single-purpose reservoir of 116,900 acre-feet of flow regulation storage located on the North Pacolet River. The estimated cost of this reservoir is $13,225,000 or an average annual cost of $526,000.

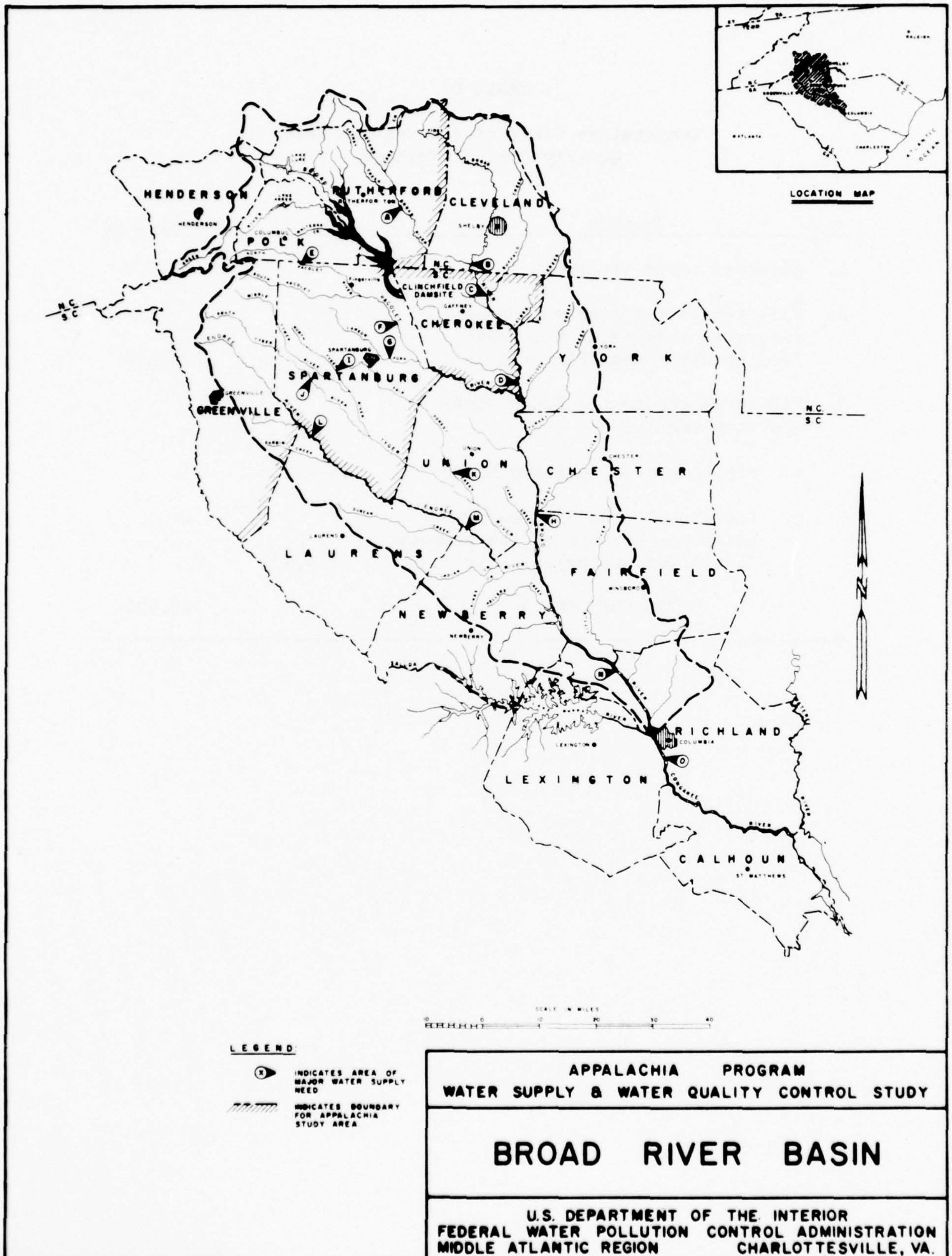
The third method, piping the wastes from the Spartanburg area to the Broad River for discharge after receiving secondary treatment, would result in an initial cost of $7,830,000 and an average annual cost of $312,000. Storage of 48,300 acre-feet of quality control water will be necessary to maintain water quality on the Broad River. The proposed Clinchfield site could be utilized for a single-purpose reservoir to provide this storage. Construction cost is estimated at $10,400,000, which results in an estimated average annual cost of $414,000. The total average cost of this method is estimated to be $726,000.

The value of annual benefits for flow regulation in the Broad River Basin is equal to the cost of the most feasible alternate, and the benefit value is estimated to be $526,000 per year. Table 6 summarizes the costs of the feasible schemes by which water quality could be maintained.

TABLE 6

Comparative Costs of Alternative Water Quality Control Methods

Method			Annual Cost
1.	Advanced waste treatment		$681,000
2.	Flow regulation single-purpose reservoir located on the North Pacolet River near Fingerville		526,000
3.	Piping wastes to the Broad River and flow regulation		
	a. Piping wastes to Broad River	$312,000	
	b. Flow regulation single-purpose reservoir located at the proposed Clinchfield reservoir site	414,000	
	TOTAL COST NO. 3		726,000



HENDERSON
RUTHERFORD
CLEVELAND
POLK
N.C.
S.C.
CLINCHFIELD DAMSITE
CHEROKEE
YORK
SPARTANBURG
GREENVILLE
UNION
CHESTER
LAURENS
FAIRFIELD
NEWBERRY
RICHLAND
LEXINGTON
CALHOUN
LOCATION MAP
LEGEND
INDICATES AREA OF MAJOR WATER SUPPLY NEED
INDICATES BOUNDARY FOR APPALACHIA STUDY AREA
APPALACHIA PROGRAM
WATER SUPPLY & WATER QUALITY CONTROL STUDY
BROAD RIVER BASIN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION CHARLOTTESVILLE, VA.

Figure 1

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

Reddies Reservoir
Roaring Reservoir
Mitchell Reservoir
Fisher Reservoir
Upper Donnaha Reservoir

YADKIN RIVER BASIN, NORTH CAROLINA

Prepared for

U. S. Department of the Army
Corps of Engineers - Appalachia Study
U. S. Army Engineer District
Charleston, South Carolina

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Middle Atlantic Region
Charlottesville, Virginia

October 1967

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I. REQUEST AND AUTHORITY

In a letter dated July 22, 1965, the Department of the Army, Corps of Engineers, Charleston, South Carolina, requested the Regional Program Director, U. S. Public Health Service, Charlottesville, Virginia[1], to prepare an estimate of present and projected needs for water supply and water quality control in the Yadkin-Pee Dee River Basin that could be provided by reservoirs on the Yadkin River and tributary streams.

This report was prepared under the authority of the Appalachian Regional Development Act of October 1965, P.L. 89-4, Section 206C.

II. PURPOSE AND SCOPE

The purpose of this investigation was to determine the need for and value of water supply and water quality control storage in the Upper Yadkin River Basin, North Carolina. Future needs were estimated utilizing economic projections provided by the Corps of Engineers that reflect the effects of the Appalachian Program on the study area.

The scope of this report was confined to that portion of the Yadkin River Basin which lies within the Appalachian Study area, as shown in Figure 1. The counties included in this area are Davie, Forsyth, Stokes, Surry, Wilkes, and Yadkin, each of which is in North Carolina. To facilitate the investigation, municipal and industrial centers located in and around Winston-Salem, Mt. Airy, Elkin, and Wilkesboro were grouped into single study units referred to in this report as subareas bearing the names of these towns.

Within the study area are the W. Kerr Scott Reservoir and five proposed reservoirs. The W. Kerr Scott Reservoir was completed in 1962 and is located on the Yadkin River near North Wilkesboro, North Carolina, approximately 90 miles upstream from Winston-Salem. It is a multi-purpose flood prevention and water supply reservoir, having a 33,000 acre-foot conservation pool allocated to Winston-Salem and Wilkes County, North Carolina, for water supply.

Of the five proposed reservoirs, the Upper Donnaha Reservoir site is located on the Yadkin River approximately 45 miles upstream from

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[1] Certain water pollution control functions of this organization were reorganized under the Federal Water Pollution Control Administration, which was subsequently transferred to the Department of the Interior on May 10, 1966.

Winston-Salem, and the remaining four sites are on tributaries to the Yadkin River between the W. Kerr Scott Reservoir and the Upper Donnaha Reservoir (see Figure 1). These four tributary reservoir sites are located on the Reddies, Roaring, Mitchell, and Fisher Rivers and bear the names of the respective rivers.

The Upper Yadkin River Basin extends into two physiographic regions. Headwaters rise in the Blue Ridge Mountains and flow through the Piedmont Plateau. Headwater sources are 3,500 to 4,000 feet above sea level, but quickly drop to 1,500 feet. Streambed slopes diminish from 8.1 feet per mile in the western Piedmont to 2.4 feet per mile before leaving the Appalachian Region. The 25-year, 7-day low flow in the Yadkin River at Wilkesboro is about 160 cubic feet per second (cfs); while near Winston-Salem it is about 590 cfs. The drainage area contributing to the Yadkin River in the study area is approximately 2,400 square miles, and the average flow from this area is 2,900 cfs.

III. SUMMARY OF FINDINGS

By the year 2020, the water supply needs for the various subareas are estimated as follows:

Subarea	Million Gallons Per Day (mgd)
Winston-Salem	120
Mt. Airy	14
Elkin	48
Wilkesboro	33

Studies indicate that releases from the 33,000 acre-foot conservation pool of the W. Kerr Scott Reservoir and natural stream flows of the Yadkin and tributaries will meet the total water supply demand in the study area until the year 2020.

Within the study area, the greatest need for water quality control is in the critical reach of the Yadkin River which extends from Muddy Creek downstream to a point just above the confluence with the South Yadkin River. The waste loads entering this reach are primarily from waste sources located in the lower part of the study area which includes the Winston-Salem subarea. Natural stream flow in the Yadkin River upstream from this point is adequate to maintain beneficial stream uses until the year 2020, based upon 85 percent removal of first stage biochemical oxygen demand (BOD). These beneficial uses, which include fishing, aesthetics,

and recreation exclusive of water contact sports, will be maintained in the critical reach until the year 2020, if 35,000 acre-feet of water quality storage is provided in any one of the five proposed reservoirs, or if advanced waste treatment is provided for the Winston-Salem subarea. Water quality storage in a single-purpose reservoir located on Roaring River was found to be the least costly alternative, and the average annual value of benefits for this water quality storage was estimated to be $336,800. The value of benefits was based upon a 50-year amortization of capital costs at an interest rate of three and one-eighth percent plus estimated annual operation and maintenance costs.

IV. PRESENT WATER USE

There is an abundant supply of water in the Yadkin River, tributaries, and the W. Kerr Scott Reservoir to meet present needs in the Winston-Salem, Elkin, and Wilkesboro subareas. The 33,000 acre-foot conservation pool in the W. Kerr Scott Reservoir is allocated to Winston-Salem and Wilkes County, North Carolina, for water supply; and the responsibility for its regulation has been given to Winston-Salem. Mt. Airy obtains its water supply from Lovills Creek, which adequately supplies present use. The present municipal and industrial water use in the various subareas is as follows:

Winston-Salem	18.3 mgd
Mt. Airy	2.2 mgd
Elkin	3.9 mgd
Wilkesboro	3.6 mgd

V. PRESENT WATER QUALITY

Water quality information collected by the State of North Carolina and the U. S. Geological Survey indicates that within the study area, the Yadkin River is generally of good mineral quality and contains relatively high concentrations of dissolved oxygen. The largest waste load entering the Upper Yadkin River comes from Winston-Salem, through Muddy Creek. While conditions in Muddy Creek are often poor, the water quality in the Yadkin River just downstream from Muddy Creek is relatively good, with the dissolved oxygen level averaging more than 6.0 milligrams per liter (mg/l) during the critical summer months. Typical values for other quality parameters in this reach are as follows:

Suspended Solids	250.0 mg/l
Dissolved Solids	70.0 mg/l
Ammonia	1.1 mg/l
BOD (5-day @ 20°C)	2.0 mg/l
Nitrate	0.55 mg/l
Nitrite	0.05 mg/l

The City of Winston-Salem operates a secondary treatment plant which discharges into Salem Creek, a tributary to Muddy Creek. Natural flows in these streams are small in comparison with the waste load entering them; and as a result, the dissolved oxygen level drops below 1.0 mg/l at times during the summer months. The City is currently planning improvements to the waste treatment plant which will improve the water quality in Muddy Creek. Tobacco and textile industries are the principal non-domestic waste sources in Winston-Salem, having discharges averaging 6.3 and 1.5 mgd, respectively, while the waste discharges from domestic sources average 7.5 mgd. Other miscellaneous sources average 1.2 mgd.

The Town of Mt. Airy operates a secondary sewage treatment plant which serves a population of approximately 7,200. The design capacity of the plant is 2.0 mgd; and its effluent, which averages 1.50 mgd, is discharged into the Ararat River. The Ararat River, which is a relatively high quality stream with a dissolved oxygen level averaging more than 7.0 mg/l during the summer, assimilates the remaining biochemical oxygen demand from Mt. Airy before reaching the Yadkin River.

The Town of Wlkin discharges the effluent from its primary sewage treatment plant, after chlorination, into the Yadkin River. The plant, averaging 0.2 mgd and having a design capacity of 0.5 mgd, serves a population of approximately 3,000, including the domestic service from local industry. The Town is currently planning a secondary treatment plant. The Town of Jonesville, which was included in the Elkin subarea for purposes of this study, discharges the effluent from a primary treatment facility serving a population of approximately 1,400 into a tributary to the Yadkin River near Elkin. The largest waste load discharging into the river from this subarea is attributable to the textile industry. This waste receives secondary treatment, and it has a population equivalent of approximately 5,500 upon entering the stream. The dissolved oxygen in the Yadkin River, immediately below this subarea, averages more than 7.0 mg/l during the summer.

The Towns of Wilkesboro and North Wilkesboro and surrounding communities were combined into a single subarea for this study. This subarea is situated on both sides of the Yadkin River just below

the W. Kerr Scott Reservoir. One of the largest poultry processing plants in the world is located in Wilkesboro. It processes an average of 180,000 chickens per eight-hour day, and discharges its wastes into the Wilkesboro secondary waste treatment plant which achieves an average of approximately 90 percent BOD removal prior to release into the Yadkin River. The BOD of the effluent from this plant averages 26 mg/l in an average discharge of 1.80 mgd. The sewage treatment facility in North Wilkesboro consists of a primary treatment plant with chlorination which handles approximately 0.3 mgd, principally of domestic origin. The dissolved oxygen in the Yadkin River immediately below this subarea averages more than 6.5 mg/l. Studies are currently underway to provide secondary treatment facilities.

VI. THE ECONOMY

In the study area, the level of economic activity as measured in terms of per capita income is greater than the State of North Carolina, but is below that of the United States as a whole.

Unless otherwise stated, all data used in this economic analysis of the study area are provided by the U. S. Army Corps of Engineers, Office of Appalachian Studies.

Manufacturing Output

The following table lists only major water users and their projected indexes of output through 2020 as computed from employment projections and gross output per employee projections.

MANUFACTURING OUTPUT

County	SIC	Industry	1960 Output ($1,000)	Index 1960 = 100 1980	2000	2020
Davie	226	Textile Finishing	30,075	400	1,000	2,000
Forsyth	211	Cigarettes	*	200	700	1,000
	221	Fabric Mills	1,640	300	500	800
	225	Knitting Mills	33,438	500	1,000	2,000
	226	Dying and Finishing Textiles	2,610	300	600	1,100
	228	Yarn & Thread Mills	5,006	300	500	800
	335	Nonferrous Rolling & Drawing	1,068	200	400	600
	366	Communications Equipment	573,422	400	800	1,600

MANUFACTURING OUTPUT (Continued)

County	SIC	Industry	1960 Output ($1,000)	Index 1960 = 100 1980	2000	2020
Stokes	2141	Tobacco	*	200	400	700
	2241	Narrow Fabric Mills	2,144	400	800	1,600
Surry	2015	Poultry & Small Game	587	400	1,000	2,000
	222	Broad Woven Fabrics				
	223	Broad Woven Fabrics	18,537	400	1,000	2,000
	224	Narrow Fabrics				
	225	Knitting Mills	9,531	400	800	1,200
	3079	Miscellaneous Plastics	*	300	700	1,500
Wilkes	2015	Poultry & Small Game	3,518	600	1,200	2,000
	225	Knitting Mills	1,674	400	800	1,200
Yadkin	224	Narrow Fabrics	341	400	900	1,500

* Data not available.

Population

Below is a table showing 1960 population in the study area and projections of future population and water service area growth through 2020.

POPULATION

County and Water Service Area	1960	1980	2000	2020
Davie County	16,728	23,280	40,280	64,961
Forsyth County	189,428	263,646	456,171	735,672
Winston-Salem	138,600	149,400	246,900	349,000
Stokes County	22,314	31,079	53,774	86,722
Surry County	48,205	67,105	116,107	187,247
Mount Airy Town	12,000	15,700	24,700	38,900
Wilkes County	45,269	63,031	109,058	175,879
N. Wilkesboro Town	7,000	17,200	33,200	67,800
Yadkin County	22,804	31,718	54,882	88,508
Jonesville, Elkin	4,900	7,048	12,000	19,400
TOTAL (County)	344,748	479,859	830,272	1,338,989
(Population Served)	162,500	189,348	316,900	476,000

In 1960, 344,748 or 7.5 percent of the population of North Carolina lived in the study area, of which 47.1 percent received municipal water service. Forsyth County had the largest population, with most of its people living in Winston-Salem.

By 2020, the population of the area will almost quadruple, the area's growth rate being 2.28 percent per year as compared to the national rate of 1.66 percent, according to data provided by the Office of Business Economics.

VII. WATER SUPPLY NEEDS

Based on the economic and demographic studies made of the basin, which reflect the effects of the Appalachian Program, domestic water use is expected to triple within the study area, while the combined water consumption by the principal water-using industries is expected to increase approximately eight and one-half times by the year 2020. The principal water-using industries in the study area are textiles, tobacco, and poultry processing.

The 33,000 acre-foot conservation pool in the existing W. Kerr Scott Reservoir is allocated to the purpose of water supply and will be adequate to meet the water supply needs of the Winston-Salem, Elkin, and Wilkesboro subareas until the year 2020. Based on U. S. Geological Survey stream flow records, the combined flow of the Ararat River at Mt. Airy and Stewarts Creek near Mt. Airy will be more than adequate to meet the Mt. Airy supply needs until the year 2020. Plans are currently underway to construct a water supply intake in Stewarts Creek.

The table below lists the estimated future municipal and industrial water supply needs for the various subareas in the basin.

	1980	2000	2020
Winston-Salem	32 mgd	70 mgd	120 mgd
Mt. Airy	6 mgd	10 mgd	14 mgd
Elkin	11 mgd	26 mgd	48 mgd
Wilkesboro	10 mgd	19 mgd	33 mgd

VIII. WATER QUALITY CONTROL NEEDS

The beneficial water uses in the study area are fishing, recreation, aesthetics, and water supply. Water quality and stream uses were

evaluated, and it was determined that coliform bacteria and dissolved oxygen were the most significant quality standards that must be maintained to protect the present and future uses of the streams in the basin.

The North Carolina State Stream Sanitation Committee has established water quality standards and stream uses for all waters in the Yadkin River Basin. The following table indicates the water uses to be protected on the main stem of the Yadkin River in the study area.

Reach	Classification	Best Usage
Source to W. Kerr Scott Reservoir	C	Fishing
W. Kerr Scott Reservoir	B	Bathing
W. Kerr Scott Reservoir to Moravian Creek	A-II	Water supply
Moravian Creek to Roaring River	C	Fishing
Roaring River to Elkin River	A-II	Water supply
Elkin River to Ararat River	C	Fishing
Ararat River to High Rock Reservoir	A-II	Water Supply

A minimum dissolved oxygen level of 4.0 mg/l has been adopted for the above classifications, and the coliform concentration for reaches designated for water supply must meet the recommendations contained in the 1946 Public Health Service Bulletin No. 296. For recreational waters, the objective is 200 fecal coliform per 100 ml.

Water supply and recreational uses in the basin will be protected through disinfection of the wastes at the source. Fishing usages can be maintained in the basin at present through provision of secondary treatment for all waste sources in the basin. To maintain this usage in the future, advanced waste treatment or flow augmentation will be necessary.

Natural flows in the Yadkin River and disinfection of waste discharges will maintain the above beneficial uses until the year 2020, except in the critical reach below the confluence with Muddy Creek. A mathematical model of the basin was developed which incorporated hydrologic data with the economic and demographic projections; and utilizing computer techniques to evaluate the model under various conditions, it was determined that the following

flows will be necessary in the Yadkin just above the confluence with Muddy Creek to maintain the beneficial uses of the river. In addition, these flows will maintain aesthetically pleasing conditions and a balanced aquatic environment.

Month	Year 1980	Year 2000	Year 2020
January	60	120	215
February	65	125	225
March	85	185	320
April	120	300	500
May	160	440	740
June	215	600	1,020
July	250	700	1,180
August	225	640	1,090
September	190	520	880
October	120	300	500
November	90	210	360
December	70	130	260

The above flows are based on the collection and adequate treatment of all municipal and industrial wastes. For the purpose of this report, adequate treatment is defined as secondary treatment with 85 percent removal of first stage BOD from all waste sources.

The above flows are not release schedules but are the estimated stream flows required in the critical reach and are based on economic projections and associated waste loads. These flows were used for determining reservoir storage requirements. Water quality releases should be made on the basis of stream needs as determined by the responsible water pollution control agency from data obtained through water quality monitors.

A mathematical model was utilized to determine the amount of storage that would be required at the various proposed reservoir sites to maintain the above flows and protect the beneficial stream uses. It was determined that 35,000 acre-feet of water quality storage in any one of the proposed reservoirs will provide sufficient water for flow regulation such that there will be no more than a five percent chance in any given year that the dissolved oxygen will drop below 4.0 mg/l for periods exceeding 30 days. This will usually occur during the summer months and would not result in a total contravention of beneficial uses. For example, it is recognized that warm-water fish will survive for extended periods at dissolved oxygen levels in the range of 3.0 mg/l.

It is desirable to release water of adequate quality from the reservoirs to meet downstream quality needs. Therefore, provision for multiple level outlets should be considered in the design of the structures to permit selection of water quality necessary for the desired uses.

IX. BENEFITS

Water Supply

Since the water supply needs in the study area will be met by natural stream flows and releases from the existing W. Kerr Scott Reservoir until the year 2020, no water supply benefits would accrue to the proposed reservoirs.

Water Quality Control

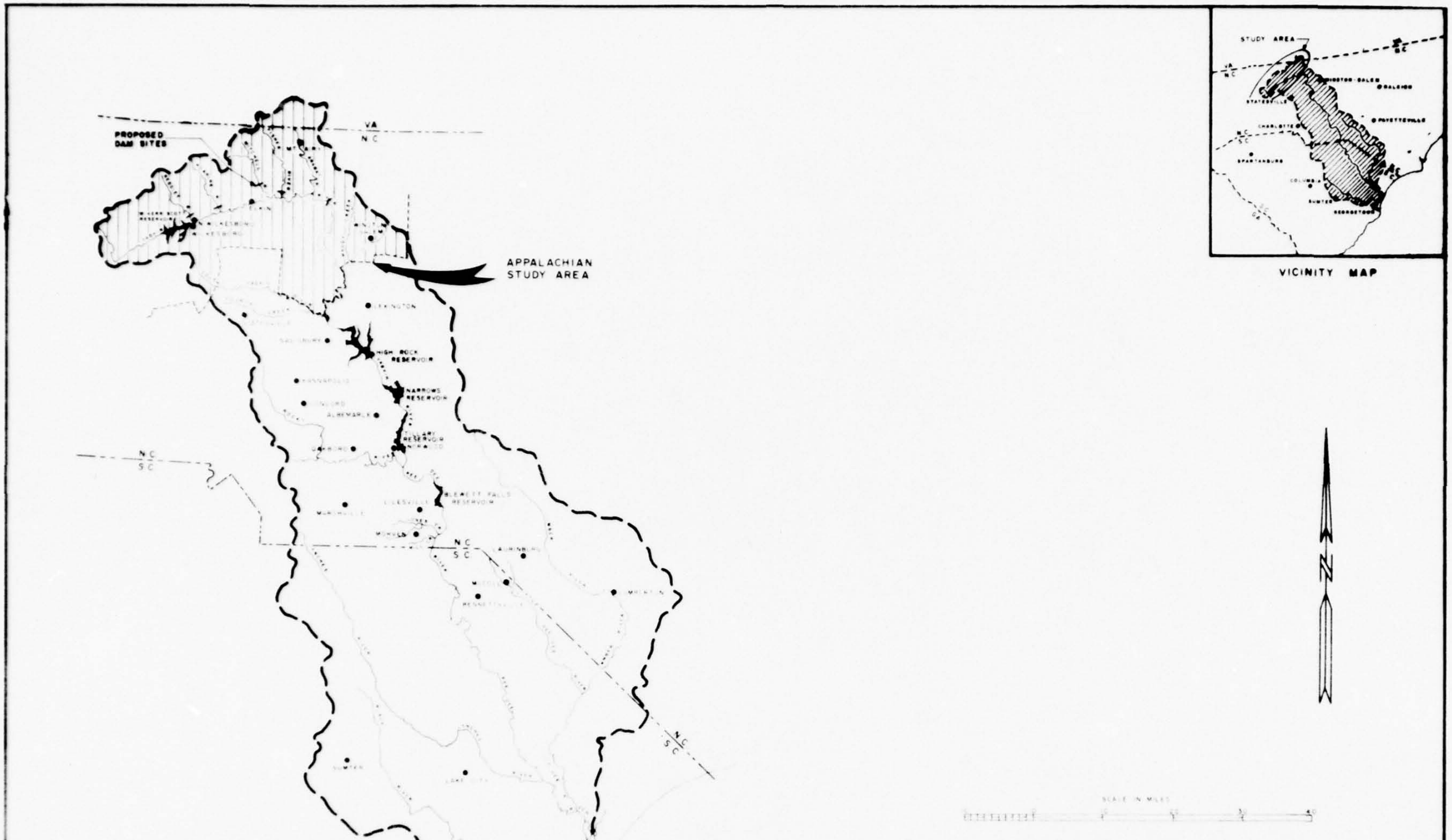
Advanced waste treatment in the Winston-Salem subarea or 35,000 acre-feet of water quality control storage in any one of the five proposed reservoirs could provide the necessary water quality control to satisfy the beneficial water uses in the study area. Information provided by the Corps of Engineers indicated that the site for the least expensive single-purpose reservoir was on Roaring River. The cost of advanced waste treatment was based upon stage construction of a lime-alum coagulation waste treatment facility. Comparison of the costs of these alternate methods is given below.

Comparative Costs of Alternative Water Quality Control Methods

Method	Annual Cost[1]
Advanced Waste Treatment	$975,500
35,000 acre-foot single-purpose water quality reservoir on the Roaring River	$336,800

[1] All of the annual cost values are based on a 50-year amortization of capital costs at an interest rate of three and one-eighth percent plus estimated operation and maintenance.

Water quality storage in the Roaring River Reservoir is the least costly alternative means of providing water quality control in the basin and may be considered equal to the value of benefits resulting from maintaining beneficial stream uses. The average annual value of benefits allocated to this purpose is $336,800.



APPALACHIA PROGRAM
WATER QUALITY CONTROL STUDY

YADKIN PEEDEE RIVER BASIN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION CHARLOTTESVILLE, VA.

Figure 1

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

HIPES RESERVOIR

Craig Creek, Virginia

Prepared for

U. S. Department of the Army
Corps of Engineers - Appalachia Study
U. S. Army Engineer District
Baltimore, Maryland

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Middle Atlantic Region
Charlottesville, Virginia

February 1968

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I. REQUEST AND AUTHORITY

The U. S. Department of the Army, District Engineer, Norfolk, Virginia, requested through a letter dated October 20, 1967, that the Federal Water Pollution Control Administration Regional Director, Middle Atlantic Region, prepare a report indicating the estimated flow needed to satisfy present and future water supply and water quality control requirements in critical areas downstream from the proposed Appalachia Project of Hipes Reservoir on Craig Creek in the James River Basin.

This report was prepared under the authority of the Appalachian Regional Development Act of 1965, P.L. 89-4, Section 206C.

II. ACKNOWLEDGMENTS

The assistance and cooperation of various governmental agencies, industrial representatives, and institutions which enabled the Chesapeake Field Station to evaluate water supply and water quality control needs were sought and are gratefully acknowledged. Cooperation was received from individuals and organizations too numerous to be listed, but special mention is merited by the following:

U. S. Fish and Wildlife Service
U. S. Geological Survey
U. S. Army, Corps of Engineers, Norfolk District
U. S. Department of Commerce
Virginia Division of Industrial Planning and Development
Virginia Division of Water Resources
Virginia State Water Control Board
Virginia State Department of Health
Virginia Institute of Marine Science
Virginia Military Institute Research Laboratories
City of Richmond, Department of Public Works
West Virginia Pulp and Paper Company, Covington, Virginia
Owens-Illinois Paper Company, Big Island, Virginia
Mead Corporation, Lynchburg, Virginia

III. PURPOSE AND SCOPE

The purpose of this investigation was to determine the need for and value of water supply and water quality control storage in the proposed Hipes Reservoir on Craig Creek, a tributary to the James River.

Water needs are based on population and economic projections prepared by the National Planning Association, Washington, D. C., for the Federal Water Pollution Control Administration, Middle Atlantic Region, and the Department of the Army, Norfolk District of the Corps of Engineers.[1]

Responsibility for water quality control activities was transferred from the Department of Health, Education, and Welfare to the Department of the Interior by Reorganization Plan No. 2 of 1966, effective May 10, 1966.

The scope of this report is limited to the main stem of the James from the confluence of Craig Creek to and including the upper James Estuary immediately below the City of Richmond (Figure 1). Benefits to water quality in the lower James Estuary are minimal and are not included.

IV. SUMMARY OF FINDINGS

Recent developments in the technology of water quality and hydrologic analysis were used in the rapid determination of accurate estimates of the effects of flow augmentation on water quality in the James River. Water quality and related information compiled by the Chesapeake Field Station, FWPCA, and the Virginia Military Institute for a comprehensive study of the James River Basin were used to verify the mathematical model of the River. The verified models were used to determine the specific benefits to water quality due to flow releases from Hipes Reservoir.

Less amenable to analysis and beyond the scope of the request are the incidental and frequently intangible benefits. The serendipity is evidenced in the aesthetical, recreational, and property value enhancement factors which should also be considered in evaluation of the findings which follow.

1. The combined population of the two major areas, Lynchburg and Richmond, within the range of the project's influence, is projected to increase from 470,000 in 1960 to 906,000 in 2020.

2. Using 1960 as a base, industrial production for the major water-using and waste-producing industries is projected to have an average increase of 300 percent by the year 1990.

3. The existing and potential surface and ground water resources are adequate to meet the current and projected municipal and industrial water supply needs that are within the range of influence of the project; hence, there are no water supply benefits attributable to the project.

4. The approved Corps of Engineers' Gathright Project on the Jackson River is expected to meet adequately the water quality control flow requirements of the James Basin until 1980, assuming a minimum of secondary treatment (85 percent removal of BOD) of all wastes downstream through Richmond.

5. After 1980, water quality objectives in the main stem of the James River can be met by providing secondary treatment of all downstream wastes and 128,000 acre-feet of water quality control storage in the Hipes Reservoir Project. The cost of this volume of storage in a single-purpose reservoir at the Hipes site is estimated to be 11.21 million dollars.* The benefits associated with this storage would be equal to the cost of the least costly alternative for maintaining downstream water quality objectives. These benefits are estimated to be 9.74 million dollars.*

6. By providing higher levels of waste treatment at Lynchburg and Richmond, the storage requirements for water quality control in the Basin could be reduced. The provision of 90 percent BOD removal from the wastes at Richmond after 1995 would reduce the required water quality control storage to 75,000 acre-feet. The Stonehouse Reservoir Project on Catawba Creek would be the least costly alternative for developing this volume of water quality control storage. This combination of storage and treatment is the least costly alternative for meeting the water quality objectives in the James River and is estimated to cost 9.74 million dollars.*

7. The need for storage for water quality control can be eliminated by an investment of 5.4 million dollars* in advanced waste treatment over the next 25 years, or 15.7 million dollars* over the next 50 years, using present technology.

V. PROJECT DESCRIPTION

As part of the Appalachia Program, the Norfolk District Corps of Engineers has added the Hipes Reservoir site to the Gathright site previously authorized for investigation of storage for flow augmentation as a means for water quality control downstream in the James River.

Gathright is a multiple-purpose reservoir on the Jackson River approximately 19 miles upstream from Covington, Virginia, and will provide 60,700 acre-feet of storage for flood control, recreation, and water quality control.

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* Present worth (1970)

Hipes Reservoir is to be located on Craig Creek, with the dam site 14.8 miles upstream from its confluence with the James River at River Mile 323.7 (Figure 1).

The two reaches of James River where significant potential water supply and/or water quality benefits exist are in the Lynchburg and Richmond areas. Both areas are at appreciable distances downstream from the Hipes project site. Lynchburg is located on the eastern edge of the Blue Ridge Mountains at about River Mile 250 on the James. Richmond is situated in the Fall Zone below which the James becomes a tidal estuary. On the basis of present knowledge, an evaluation of benefits of the project to these two areas is considered to be a good approximation of the total water supply and water quality control benefits attributable to the project.

VI. WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

Water resource management plans attempt to relate the demand to the availability and strive to assure that the demands are met with some predictable reliability. The demand imposed upon the water resources of a given area is a function of the socio-economic and related land use characteristics of the area. The availability depends on the hydrologic characteristics of the area.

A. The Demands of the Domestic Environment

1. Population Growth

In 1960 the James River Basin had a population of about 1.7 million. Lynchburg and Richmond, the two locations on the James where benefits from storage at Hipes may be significant, had a combined total population of 580,972. Both of these areas are expected to increase in population at a faster rate than the Basin as a whole. Table 1 shows the projected populations of the Lynchburg and Richmond areas and for the James River as a whole.

2. Municipal Water Supply

The municipally owned water system for Lynchburg uses surface water from an impounding reservoir on Pedlar River in Amherst County. This reservoir impounds 1,860 acre-feet, and the drainage area above the dam is 33.2 square miles. In addition, the City maintains a pump station on the James River where a supply can be obtained during emergencies or for other reasons. The water is filtered and chlorinated in a plant having a total capacity of 15 million gallons per day. Storage for filtered water is provided

TABLE 1

POPULATION PROJECTIONS

Year	Lynchburg Area(1)	Richmond Area(1)	James Basin
1960	85,681	383,371	1,728,900
1965(2)	95,000	420,000	
1970	107,000	453,000	
1980	143,000	565,000	
1990	193,000	676,000	2,835,200
2000	253,000	754,000	
2010	329,000	827,000	
2020	420,000	906,000	4,405,900

(1) See Appendix A for area definition.

(2) Interpolated.

throughout the distribution system in ten reservoirs with a combined capacity of 23,978,000 gallons. The present daily consumption varies from 7.0 to 12.0 million gallons per day.[3] About 80 percent of the area population is served.

The municipally owned water system for Richmond obtains water from the James River which has a drainage area of 6,757 square miles above the intake. The water is chemically treated, filtered, and chlorinated in a plant with rated capacity of 66 million gallons per day and maximum capacity of 80 million gallons per day. The present daily consumption varies from 30 to 50 million gallons per day.[3] This system serves about 80 percent of the area population, but numerous smaller community systems in the area served by municipally owned systems raise the percentage of the population served to about 93 percent.

The population projections constitute the base upon which municipal water needs were projected. Figure 2 was developed from a statistical evaluation of municipal water supply systems in the nation.[4] From these graphs the per capita water consumption was estimated. This was applied to the increase in population as the service area expanded to obtain an estimate of the average municipal water supply requirements. The resulting estimate, therefore, reflects not only the increasing per capita water demands, but also the expected increase in percentage of population served by municipal systems. Table 2 summarizes the municipal water supply needs projected for the Lynchburg and Richmond areas.

TABLE 2

PROJECTED MUNICIPAL WATER NEEDS

Area[1]	1980 Demand			2000 Demand			2020 Demand		
	Population Served	gcd[2]	Usage (mgd)	Population Served	gcd[2]	Usage (mgd)	Population Served	gcd[2]	Usage (mgd)
Lynchburg	143,000	125	18	253,000	145	37	420,000	145	61
Richmond	565,000	125	71	754,000	145	110	906,000	145	130

(1) For definition of areas, see Appendix A.

(2) From Figure 2.

3. Municipal Waste Loads

The City of Lynchburg provides sewerage and a primary waste treatment plant for a design population of 70,000. The plant discharges an average 5-day BOD load of 6,500 pounds per day, based upon 1966 operating records.

The City of Richmond presently provides primary treatment for 70 percent of its sewered wastes. The remaining 30 percent discharges untreated to the James River through several combined sewers. The City's plans call for completion of a secondary waste treatment plant capable of handling all municipal wastes by 1971.

For planning purposes, Lynchburg waste loads were projected on the basis of population and a per capita BOD-5 contribution of 0.17/lb/cap/day. The waste load projections for Richmond were obtained from consultant reports.[5] As in the case of water supply projections, consideration was given for an increasingly larger percentage of the area population to be served. Table 3 shows the projected municipal waste production at Lynchburg and Richmond through the year 2020. For preparation of treatment plant design estimates, this 50-year outlook has been divided into two 25-year periods.

B. The Impact of the Industrial Environment

1. Industrial Growth

Although there are many varieties of industry represented along the James River, two major groups, the pulp and paper and the chemical groups, exert the greatest demand on the water resources of the portion of the river that would be influenced significantly by a reservoir on Craig Creek. Table 4 shows the projected increase in industrial production for these manufacturing groups within the geographical areas where representative companies are presently located. The production indices are derived from projected employment, with adjustments made to account for expected changes in product output per employee.[3]

TABLE 3

PROJECTED MUNICIPAL WASTE LOADS

	1967			1995			2020		
Area	Population Served	Volume (mgd)	Untreated BOD-5 (lb/day)	Population Served	Volume (mgd)	Untreated BOD-5 (lb/day)	Population Served	Volume (mgd)	Untreated BOD-5 (lb/day)
Lynchburg(1)	56,000	6.5	11,000	200,000	23.0	34,000	380,000	44.0	65,000
Richmond(2)	250,000	60.0	85,000	715,000	120.0	140,000	906,000	165.0	215,000

(1) Lynchburg municipal waste BOD based upon 0.17 lb/cap/day of BOD-5.

(2) Richmond waste characteristics obtained from Greeley and Hansen consultant report for the City of Richmond.

TABLE 4

INDUSTRIAL GROWTH-PROJECTED
INDICES OF PRODUCTION

Area	Type of Industry	SIC(1)	Index of Production, 1960 = 100 1970	1980	1990
Big Island (Bedford Co.)	Pulp & Paper	2631	200	200	200
Lynchburg	Pulp & Paper	2631	115	98	90
Richmond	Pulp & Paper	2621	103	80	83
	Pulp & Paper	2631	218	354	781
	Chemical	2823	168	257	337

(1) Standard Industrial Classification.

2. Industrial Water Supply

In the Lynchburg area two paper companies dominate the industrial water supply usage. Owens-Illinois Paper Company withdraws an average of 10.0 mgd from the James about 15 miles upstream from Lynchburg. Mead Corporation withdraws about the same amount from the James at Lynchburg. There are several other industries in the Lynchburg area, many of which utilize public supplies, but none of which imposes a significant demand on the water resources of the area.

Of the many companies located in the Richmond area, only four are of measurable significance with respect to the locale's water resources. Federal Paperboard has two plants that utilize a combined average of 2.25 mgd; Albermarle Paper Company requires about 10.0 mgd of process water;* Standard Paper Company uses 5.5 mgd of surface water; and the E. I. duPont Company (Spruance Plant) uses about 6.0 mgd of process water which it obtains from the tidewater James.

Cooling water requirements for such purposes as power production have not been included in the analysis due to the expected influences of proposed stream standards on thermal discharges and possible use of cooling towers.

* The large quantities of cooling water diversion by this company have not been considered in water supply projections.

Projected industrial water supply requirements have been made on the basis of the indices of output listed in Table 4. Water requirements were considered to be directly proportional to production. There is, however, a trend on the part of large water-using industries to reduce the net amount of water needed per unit of product.[6] Advances in production technology can be expected to result in even greater recirculation and reuse of process waters. In an effort to account for this expected attenuation of industrial water requirements, water supply needs for industrial purposes were considered to level off at the 1990 value. Table 5 summarizes the industrial water supply needs projected for the appropriate areas.

TABLE 5

PROJECTED INDUSTRIAL WATER SUPPLY NEEDS

Area	SIC[1]	Average Process Water Use in MGD			
		1967	1980	2000	2020
Big Island					
(Bedford Co.)	2631	10.0	20.0	20.0	20.0
Lynchburg	2631	10.0	10.0	9.0	9.0
Richmond	2621	6.2	5.0	5.2	5.2
	2631	2.3	8.2	18.0	18.0
	2823[2]	7.0	18.0	24.0	24.0

(1) Standard Industrial Classification.

(2) The major representative of this industrial group presently obtains its water supply from the tidewater James.

3. Industrial Waste Production

Table 6 shows the pertinent waste characteristics of the relevant industrial groups discharging to the James River. Both of the Lynchburg area paper plants utilize waste recovery or burn their black liquor, and thereby reduce their potential BOD loads. Many of the Richmond area plants practice some form of pollution abatement or discharge to City sewers.

As in the case of industrial water supply needs, the amount of waste produced per unit of product probably will tend to decrease in the future. The waste loads, therefore, have been projected as a direct proportion to product output through 1990, with leveling off thereafter. Table 6 also shows the projected waste loads for the chief industrial groups having a bearing upon this report.

TABLE 6

PROJECTED INDUSTRIAL WASTE

Area	SIC[1]	1967 BOD-5 (lb/day)	1967 Volume (mgd)	1995 BOD-5 (lb/day)	1995 Volume (mgd)	2020 BOD-5 (lb/day)	2020 Volume (mgd)
Big Island (Bedford Co.)	2631	15,000	10.0	30,000	20.0	30,000	20.0
Lynchburg	2631	21,000	9.0	19,000	9.0	19,000	9.0
Richmond	2621	1,000	6.2	800	5.2	800	5.2
	2631	2,900	2.3	22,600	18.0	22,600	18.0
	2823[2]	8,500	7.0	28,600	24.0	28,000	24.0

(1) Standard Industrial Classification.

(2) The major representative of this industrial group presently discharges its waste to the tidewater James about five miles below the Richmond sewage treatment plant.

C. Summary of Water Supply Requirements

The projected water supply demand for the James River in the Lynchburg and Richmond areas does not exceed the corresponding minimum unregulated stream flows. The completion of Gathright Reservoir will increase the reliability of the James to meet these requirements. Table 7 summarizes the municipal and industrial (process only) needs.

D. Summary of Water Quality Control Flow Requirements

Dissolved oxygen (DO) is the water quality indicator upon which the design of control measures has been based for this study. A minimum monthly average DO concentration of 5.0 mg/l is the planning objective.

There are presently two areas, Lynchburg and Richmond, on the James and within the sphere of influence of a reservoir on Craig Creek that experience recurrent DO problems. Figure 3 exemplifies the effect of waste discharged on the DO of the River in these two vicinities. Although the provision of biological treatment would improve the existing conditions, the projected growth and resulting waste loads in these areas may require that control devices in addition to conventional waste treatment be considered. To form a basis on which to plan for possible water quality control needs, the 50-year period ending in the year 2020 has been divided into

TABLE 7

SUMMARY OF PROJECTED WATER SUPPLY REQUIREMENTS

Area	1980 Demand			2000 Demand			2020 Demand		
	Municipal (mgd)	Industrial (mgd)	Total (mgd)	Municipal (mgd)	Industrial (mgd)	Total (mgd)	Municipal (mgd)	Industrial (mgd)	Total (mgd)
Big Island (Bedford Co.)	(1)	20.0	20.0	(1)	20.0	20.0	(1)	20.0	20.0
Lynchburg	18.0	10.0	28.0	37.0	9.0	46.0	61.0	9.0	70.0
Richmond	71.0	31.0	102.0	110.0	47.0	157.0	130.0	47.0	177.0

(1) Municipal requirements are minor.

two 25-year treatment plant design periods. The river discharge by months that would be required below Lynchburg and Richmond under conditions at the present and at the end of each of the 25-year periods is shown in Tables 8 and 9 for three levels of waste treatment. It is assumed that a stream flow regulation program would provide the minimum natural flow on a non-reimbursable basis. The waste treatment levels considered are defined as follows:

Level I - Conventional secondary treatment operated at an efficiency of 85 percent removal of 5-day BOD. The provision of this level or its equivalent in BOD reduction is considered to be prerequisite to low flow augmentation.

Level II - Ninety percent removal of the 5-day BOD. This level will result in a one-third reduction in treated waste load discharges and can be achieved by design modifications of conventional biological waste treatment plants.

Level III - Ninety-five percent removal of the 5-day BOD. This level of treatment can be achieved by conventional biological treatment in combination with oxidation ponds or chemical precipitation, or some other method of advanced waste treatment.

The cost estimates shown in the Tables for each treatment level represent the annual expenditures at the beginning and end of the design period to provide either Level II or III, over and above the annual cost of Level I. Level I is considered to be a minimum level when considering low flow augmentation as an alternative to treatment. Costs were estimated from municipal treatment plant cost data compiled and analyzed by Frankel.[7] Some cost data made available by industries in the Basin have been used when applicable. The costs shown include total annual cost of operation, maintenance, and amortization of capital at three and one-eighth percent over 25 years. The interest rate chosen is the same as that used by the Corps of Engineers, Norfolk District, for reservoir construction.

The stream flow requirements necessary to assimilate the corresponding waste loads without depleting the average DO below 5.0 mg/l were computed by means of digital computer simulation models[8,9] based upon the Streeter-Phelps formulation of the oxygen sag curve. This formulation mathematically describes the interaction of the fundamental physical and biological systems that affect DO. For planning purposes, the mean monthly maximum water temperatures were used.

The probability at which the natural or regulated stream flows are expected to meet the required stream flow is a measure of the

TABLE 8

WATER QUALITY CONTROL FLOW REQUIREMENT TO MAINTAIN 5.0 mg/1
AVERAGE DO OBJECTIVE IN THE JAMES RIVER AT LYNCHBURG

Design Period		Treat-ment	Annual Cost[2] 1000's Dollars		Flow Requirements in cfs												Relia-bility
From	To	Level[1]	Initial	Final	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Factor[3]
Present	N.A.	I	N.A.	N.A.	220	240	290	420	460	690	690	690	580	450	300	250	99.5
		II	N.A.	N.A.	200	220	260	380	410	640	640	640	10	400	270	230	
		III	N.A.	N.A.	180	200	230	340	370	570	570	570	470	360	240	210	
1970	1995	I	base	base	300	300	370	550	620	900	900	900	750	580	380	320	96.6
		II	175	205	240	270	320	480	540	780	780	780	670	500	330	280	98.6
		III	745	855	210	230	280	400	450	670	670	670	570	420	290	240	99.8
1995 ·	2020	I	base	base	320	380	450	650	720	1100	1100	1100	900	700	470	400	91.9
		II	210	240	280	320	390	560	610	900	900	900	760	600	400	340	94.4
		III	1055	1180	240	270	310	450	490	700	700	700	600	470	330	280	99.5
Mean Monthly Flow[4]					4749	5822	7280	6149	4048	2437	1608	1959	1437	1919	2242	3445	
Minimum Monthly Flow[4]					631	690	2741	1798	1190	910	503	458	421	431	511	729	
Mean Monthly Maximum Temperature[5]					9	11	15	23	25	32	32	32	29	24	16	12	

(1) Treatment Levels I, II, and III represent 85, 90, and 95 percent BOD removal, respectively.

(2) Total cost including operation, maintenance, and amortization of capital at three and one-eighth percent for 25 years. (ENR = 1090)

(3) Percent of months out of 37 years of historic record that flow requirements were met. Gathright assumed operating for maximum need at Covington.

(4) From USGS gage on the James River near Holcombs Rock, Virginia.

(5) In °C from <u>Chemical and Physical Character of Surface Waters of Virginia</u>.

TABLE 9

WATER QUALITY CONTROL FLOW REQUIREMENT TO MAINTAIN 5.0 mg/l
AVERAGE DO OBJECTIVE IN THE JAMES RIVER AT RICHMOND

Design Period		Treat-ment	Annual Cost (3) 1000's Dollars		Flow Requirements in cfs												Relia-bility
From	To	Level (2)	Initial	Final	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Factor (4)
Present	N.A.	I	N.A.	N.A.	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	100.0
		II	N.A.	N.A.	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	100.0
		III	N.A.	N.A.	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	100.0
1970	1995	I	base	base	300	300	300	650	1000	1450	1550	1550	1350	900	300	300	96.2
		II	90	160	(1)	(1)	(1)	(1)	300	650	800	800	550	(1)	(1)	(1)	100.0
		III	930	1,320	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	100.0
1995	2020	I	base	base	400	400	500	950	1250	1650	1800	1800	1550	1150	600	400	94.8
		II	170	210	(1)	(1)	(1)	(1)	500	900	1050	1050	800	300	(1)	(1)	99.5
		III	1,530	1,810	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	100.0
Mean Monthly Flow (5)					10021	11662	13569	12066	7392	5238	3605	4520	3697	4138	4471	7387	
Minimum Monthly Flow (5)					1656	4103	6396	3776	3013	1684	1306	858	802	700	1113	1681	
Mean Monthly Maximum Temperature (6)					8	9	13	20	24	29	30	30	28	23	16	12	

(1) Water quality control flow requirements are less than minimum daily flow recorded.

(2) Treatment Levels I, II, and III represent 85, 90, and 95 percent BOD removal, respectively.

(3) Total annual cost including operation, maintenance, and amortization of capital at three and one-eighth percent for 25 years. (ENR = 1090)

(4) Percent of months out of 37 years of historic record that flow requirements were met. Gathright assumed operating for maximum need at Covington.

(5) From USGS gage on the James River at Richmond (adjusted to include Kanawha Canal diversion).

(6) In °C from Chemical and Physical Character of Surface Waters of Virginia.

reliability of the system. This probability is computed as the number of successful events divided by the total number of events considered. As applied to the monthly stream flow requirements, an event consists of a routing of an historical monthly average stream flow through the river system and comparing it to the corresponding monthly flow requirement. The term "reliability factor" is defined as the probability, as discussed above, multiplied by 100.

$$\text{Reliability Factor} = 100 \times \frac{\text{Number of Successful Months}}{\text{Total Number Months in Historic Record}}$$

Making use of a high speed digital computer program developed by Fiering and Pisano,[10] 37 years of historical stream flow data have been routed through the system, and reliability factors have been computed for each of the flow requirement vectors shown in Tables 8 and 9. For planning purposes, a reliability factor of 99.6 has been chosen. On the basis of monthly flows, this represents one unsuccessful month out of 20 years. As was stated earlier, it is assumed that Gathright Reservoir will be operational by the early 1970's. Hydrological routings, therefore, have been made with Gathright operating for maximum water quality control benefit. Table 10 shows the operating rules assumed for Gathright Reservoir.

VII. METHODS OF MEETING WATER SUPPLY AND WATER QUALITY CONTROL NEEDS AND THEIR ASSOCIATED COSTS

Probably the most widespread methods for meeting specific water quality objectives with respect to dissolved oxygen are (1) reduction of BOD waste loads by treatment at the source, and (2) regulation of stream flow by providing reservoir storage. Other methods, such as instream aeration, waste storage, and piping of waste to bodies of water having a greater assimilation capacity, do not presently appear to be feasible devices for pollution control in the Lynchburg and Richmond areas.

This analysis is, therefore, limited to an examination of storage and treatment, either separately or in combination, as a means of meeting the water quality control needs of the portion of the James River within the scope of this report. From an examination and cost evaluation of many possible combinations of storage and treatment, a single alternative can be selected from which the need for and value of storage in a multi-purpose reservoir on Craig Creek can be estimated. Table 11 defines the pollution control alternatives that have been considered for this report. The treatment combinations considered include all possible combinations of the

TABLE 10

GATHRIGHT RESERVOIR RELEASE RULES

Operation for Year 2020 Water Supply and Water Quality
Control Flow Requirements at Covington

Design Year	Treatment Level	Flow Past Covington in cfs											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	I	175	170	180	190	210	365	365	365	245	210	185	175
Design Temperature		9	8	12	20	21	26(1)	26(1)	26(1)	24	21	13	10

(1) Based upon controlled temperature release from Gathright.

TABLE 11

STORAGE REQUIREMENTS CORRESPONDING TO POSSIBLE COMBINATIONS OF TREATMENT LEVELS AT LYNCHBURG AND RICHMOND

Treatment Level		Required Storage
Lynchburg	Richmond	(acre-feet)
	Design Period 1970 - 1995	
I	I	75,000
I	II	27,000
I	III	27,000
II	I	75,000
II	II	0
II	III	0
III	I	75,000
III	II	0
III	III	0
	Design Period 1995 - 2020	
I	I	128,000
I	II	62,000
I	III	62,000
II	I	128,000
II	II	27,000
II	III	27,000
III	I	128,000
III	II	0
III	III	0

three treatment levels at Lynchburg and Richmond. The amount of reservoir storage that is required to meet the average DO objective of 5.0 mg/l for each of the treatment combinations has been computed by means of the hydrological simulation model developed by Fiering and Pisano.[10] Appendix B describes the procedure for computing storage.

The total pollution control alternative, therefore, consists of a specified treatment level at Lynchburg and Richmond in conjunction with a specific storage volume for stream flow regulation.

Based on engineering studies conducted by the Norfolk District Corps of Engineers, the least costly reservoir for developing water quality control storage in the study area is the Stonehouse Reservoir Project on Catawba Creek (D.A. = 111 square miles). See Figure 1. However, due to hydrologic limitations, the dependable storage at this site cannot be developed beyond approximately 85,000 acre-feet. Therefore, whenever the alternative being considered to meet downstream water quality demands required storage in excess of 85,000 acre-feet, the Stonehouse Reservoir Project was not considered.

For alternatives requiring more than 85,000 acre-feet of storage, it was assumed that the entire storage requirement would be developed at the Hipes site, the next least costly reservoir site available for developing water quality storage. Preliminary economic studies indicated it would not be feasible to develop both the Stonehouse and the Hipes Project to provide storage in excess of 85,000 acre-feet. The total costs of developing water quality control storage at either the Hipes Project or the Stonehouse Project are shown in Table 12 and Table 13.

Since the benefit of storage for water quality control is generally evaluated on the basis of a 50-year period, it is necessary to select the long-range alternative first; and then designate the minimum required short-term action plan, taking fullest advantage of the storage computed to meet the long-range needs. By so doing, the alternatives listed in Table 11 can be reduced to the six logical 50-year pollution control alternatives shown with their respective costs in Table 13.

Pollution control by treatment is generally designed for a 20- to 25-year period of useful life. For comparative purposes, the alternatives and associated costs for a 25-year plan are given in Table 12.

TABLE 12

COST COMPARISON FOR POLLUTION CONTROL ALTERNATIVES

Twenty-five Year Plan
(1970 - 1995)

Alter-native Number	Description of Alternative: Treatment Level Lynchburg	Treatment Level Richmond	Storage (acre-feet)	Cost of Alternative Present Worth 1970: Treatment	Storage[(1)] Hipes	Storage[(1)] Stonehouse	Total w/Hipes	Total w/Stonehouse
1	I	I	75,000	0.00	9.87	8.23	9.87	8.23
2	I	II	27,000	2.15	6.10	4.60	8.25	6.75
3	II	II	0	5.41	0.00	0.00	5.41	5.41
4	II	I	75,000	3.52	9.87	8.23	13.39	11.75
5	III	II	0	15.88	0.00	0.00	15.88	15.88
6	III	I	75,000	13.74	9.87	8.23	23.61	21.97
7	I	III	27,000	19.32	6.10	4.60	25.42	23.92
8	II	III	0	22.58	0.00	0.00	22.58	22.58
9	III	III	0	33.06	0.00	0.00	33.06	33.06

(1) Present worth of storage based on three and one-eighth percent interest rate. Operation and maintenance cost for the dam and appurtenances was amortized based on the design study period, i.e., 1970-2020.

TABLE 13

COST COMPARISON FOR POLLUTION CONTROL ALTERNATIVES

Fifty-Year Plan
(1970 - 2020)

Alter-native Number	Description of Alternative: 1970 - 1995 Treatment Level: Lynchburg	Richmond	1995 - 2020 Treatment Level: Lynchburg	Richmond	Storage (Ac-Ft)	Cost of Alternative Present Worth 1970: Treatment	Storage(1): w/Hipes	w/Stonehouse	Total: w/Hipes	w/Stonehouse
10	I	I	I	I	128,000	0.00	11.21	(2)	11.21	(2)
11	I	I	I	II	75,000	1.51	9.87	8.23	11.38	9.74
12	I	II	II	II	27,000	5.45	6.10	4.60	11.55	10.05
13	II	II	III	II	0	15.67	0.00	0.00	15.67	15.67
14	III	II	III	II	0	26.15	0.00	0.00	26.15	26.15
15	III	III	III	III	0	55.26	0.00	0.00	55.26	55.26

(1) Present worth of storage based on three and one-eighth percent interest rate. Operation and maintenance cost for the dam and appurtenances was amortized based on the design study period, i.e., 1970-2020.

(2) 128,000 Acre-Feet exceeds what is considered to be the dependable storage at the Stonehouse Reservoir Project.

VIII. DISCUSSION OF ALTERNATIVES

Alternatives 1 through 9 (see Table 12) are designed to meet the stream DO objective through the year 1995. These alternatives are included for comparison purposes. It is presently common practice to assume a 50-year design period for storage for water quality control. There are, however, some advantages to short-range planning in this day of rapid technological change. Advances in waste treatment technology and industrial production processes could drastically alter the water requirements and waste production of the future.

Alternates 10 through 15 are six feasible long-range (50 years) water quality control plans from which the need for and value of storage can be evaluated. Table 14 provides a subjective evaluation of these six alternatives. Although the rating of secondary effects is admittedly a somewhat arbitrary approach to making a non-monetary comparison of the different plans, it does present a method of acknowledging and considering effects that might not otherwise be included in the evaluation.

The following is a short description of each of the six 50-year plans. The particularly significant secondary effects of each are also briefly commented on.

<u>Alternate 10</u> is what can be considered the minimum acceptable treatment level in combination with 128,000 acre-feet of storage for water quality control at the Hipes site. Significant secondary benefits are increased low flows in the Fall Zone at Richmond and maximum performance stability. Since this alternative requires the minimum treatment and maximum storage, it is the least consistent with the goal of complete elimination of point-source pollution.

<u>Alternate 11</u> is the least costly alternative, and the storage requirement is reduced by about 41 percent to 75,000 acre-feet. This reduction in storage is the result of the application of the secondary treatment level at Richmond beginning in 1995 and through the year 2020. The secondary benefits of this alternative are essentially the same as Alternate 10, with an additional slight positive effect in the area of eliminating point-source pollution.

<u>Alternate 12</u> calls for the secondary treatment level at Richmond for the 1970 through 1995 design period and at both Richmond and Lynchburg for the 1995 to 2020 design period. The alternate requires 27,000 acre-feet of storage at Hipes and a total cost that is insignificantly more expensive than the least costly plan. In the subjective evaluation, losses with respect to aesthetic improvement for the Fall Zone at Richmond are balanced by gains in the ability to take advantage of technological advances.

TABLE 14

SUBJECTIVE EVALUATION OF POLLUTION CONTROL ALTERNATIVES

Secondary Effects[1]	Pollution Control Alternative 10	11	12	13	14	15
	Rating[2]					
a. Nutrient removal above Richmond for water supply and below Richmond for estuary eutrophication	2	2	2	3	3	4
b. Color removal--associated with paper industry, particularly below Lynchburg	2	2	2	3	4	4
c. Recreation--effects on river	2	2	2	2	1	1
d. Fishery--effects on river	?	?	?	?	?	?
e. Ability to take advantage of technological advances	-	1	2	3	4	4
f. Variability in performance	4	3	3	2	1	1
g. Aesthetic improvement--flow in Fall Zone at Richmond	4	4	3	2	1	1
h. Consistent with goals of complete elimination of point-source pollution	-	2	2	3	3	4
TOTAL	12	16	16	18	17	19

(1) Effects incidental to principal objective of maintaining 5.0 mg/l DO.

(2) Definition of Ratings:
- \- Negative effect
- 1 No effect
- 2 Slight positive effect
- 3 Significant effect
- 4 Very significant effect
- ? Unknown effect

Alternate 13 is almost one and one-half times more costly than the least costly alternate. The sharp rise in cost is due to the requirement of treatment level III which involves chemical precipitation and its correspondingly high operating costs. No storage above that provided by the Gathright Project is required in this alternative. The 95 percent treatment level with chemical precipitation at Lynchburg would have the secondary benefit of significant color and nutrient reduction.

Alternate 14 requires the third level of treatment at Lynchburg for both design periods and the second level of treatment at Richmond for both design periods. No flow regulation other than that provided by Gathright for the Covington area is needed. The cost is more than twice that of the least costly alternative, and the secondary benefits are somewhat higher in the nutrient and color removal categories but lower in performance variability and dependable flow in the Fall Zone.

Alternate 15 is five times as expensive as the least costly alternate due to the fact that the highest treatment level is specified for all waste contributors in the Lynchburg and Richmond areas from 1970 through 2020. As in Alternates 13 and 14, no storage is required. This alternate scores highest in secondary effects with very significant positive effects on nutrient and color removal, ability to take advantage of technological advances, and consistency with the goal of complete elimination of point-source pollution.

IX. NEED FOR AND VALUE OF STORAGE IN HIPES RESERVOIR FOR WATER SUPPLY AND WATER QUALITY CONTROL

The projected water supply demand for those areas within the sphere of influence of Hipes is within the reliable limits of the natural unregulated stream flows. Therefore, no benefits for water supply can be assigned to the project.

Alternate 11 (see Table 13) is the least costly alternative for maintaining 5.0 mg/l average DO at Lynchburg and Richmond, with a design failure no greater than one month in 20 years. This alternative requires conventional waste treatment operated at 85 percent BOD removal for the period from 1970 through 1995, with an increase to 90 percent efficiency at Richmond beginning in 1995. Also, this alternative would require 75,000 acre-feet of water quality control storage after 1980. Storage at the Stonehouse Reservoir would be the least costly means of providing this volume of water quality control storage. The total cost (present worth 1970) of Alternate 11, including storage and advanced waste treatment, is estimated to be 9.74 million dollars.

The water quality objectives at Lynchburg and Richmond can be maintained also by providing 128,000 acre-feet of low flow augmentation storage in the Hipes Reservoir Project (see Alternate 10, Table 13). The benefits to be derived from this volume of storage would be equal to the least costly alternative for maintaining the desired water quality objectives in the Basin, i.e., 9.74 million dollars (present worth 1970).

The need for storage over and above that to be provided by the Gathright Project is not expected to be required before the year 1980. It is recommended that the need for and value of storage for water supply and water quality control be re-evaluated during the final design phases to take into account possible technological advances in processes as well as improvements in the methods for computing needs.

APPENDIX A

GEOGRAPHICAL DEFINITION OF LYNCHBURG AND RICHMOND AREAS

RICHMOND AREA

Richmond City

Brookland District (Henrico County)

Fairfield District (Henrico County)

Tuckahoe District (Henrico County)

Varina District (Henrico County)

Manchester District (Chesterfield County)

Midlothian District (Chesterfield County)

Dover District (Goochland County)

(and other districts outside basin)

LYNCHBURG AREA

Lynchburg City

Elon District (Amherst County)

Brookville District (Campbell County)

Rustburg District (Campbell County)

(and Forest District, Bedford County)

APPENDIX B

METHODOLOGY OF HYDROLOGIC ANALYSIS

The hydrological analysis for storage computations has been facilitated by the application of a computer program developed by Fiering and Pisano.[10] The statistical evaluation of the flow requirements was based upon 37 years of historic stream flow records using the mean monthly stream flows. The period of record used was from October 1927 through September 1964. Figure 1-B shows the system geometry as assumed for this study. Table 1-B is a list of the USGS stream gaging stations used, and Table 2-B lists the pertinent geographical locations of the system. Gage number 6 was created for this study by adding the flows from the gage on Dunlap Creek with those at Falling Spring on the Jackson River. The resulting record was considered to be a reasonably good approximation of the flows that occur at Covington, the point of need for Gathright water quality control storage.

Figures 2-B and 3-B exemplify the method of handling the output from the program to determine storage requirements. By routing the historic flows through the system with various sizes of storage in Hipes and plotting the computed failure probabilities versus storage, the storage required to meet the desired reliability can be picked from the curve. These curves were developed for all of the alternatives considered. Only the curves for the selected alternate are shown as an example.

In the historic record of 37 years, two months' failure would exceed the objective reliability factor of one month in 20 years. However, based on observations of the records from gages for which a longer historic trace is available, it was concluded that for the limited record used, two failures (reliability factor - 99.6) would be accepted for design purposes. Future studies, perhaps utilizing synthetically generated flow references, are recommended to statistically validate this judgment decision.

TABLE 1-B

STREAM GAGES USED IN HYDROLOGIC ANALYSIS OF JAMES RIVER BASIN

Gage No.	Description	Drainage Area (square miles)
1	Jackson River at Falling Spring	409
2	James River at Lick Run	1,369
3	James River at Buchanan	2,084
4	James River at Holcombs Rock	3,250
5	James River at Bent Creek	3,671
6	Dunlap Creek plus Falling Spring gage	575
7	James River at Casterville	6,242
8	Cowpasture River near Clifton Forge	456
9	Craig Creek at Parr	331
10	Dunlap Creek near Covington	166
11	Maury River at Buena Vista	649

TABLE 2-B

DESCRIPTION OF COORDINATES FOR HYDROLOGIC ANALYSIS

Location	River Mile	Drainage Area (square miles)	Reference Gage (1)	Gage Adjustment Factors
Jackson River Gathright dam site	43.5	344	1	0.8411
Jackson River City of Covington	23.5	610	6	1.0000
Craig Creek Hipes dam site	14.8	327	9	1.0000
James River City of Lynchburg	250.0	3,250	4	1.0000
James River City of Richmond	100.0	6,760	7	1.0816

(1) See Table 1-B for gage description.

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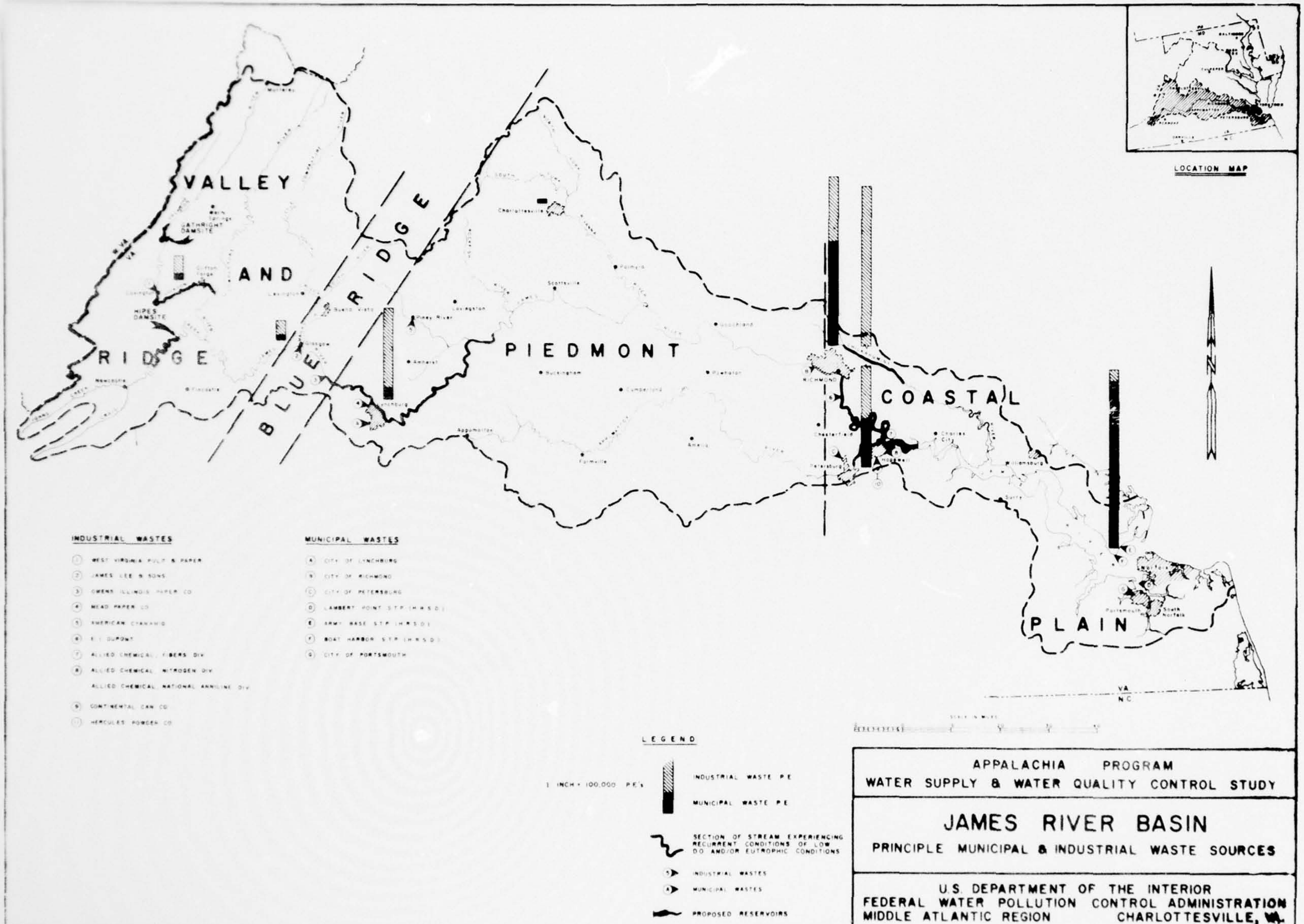
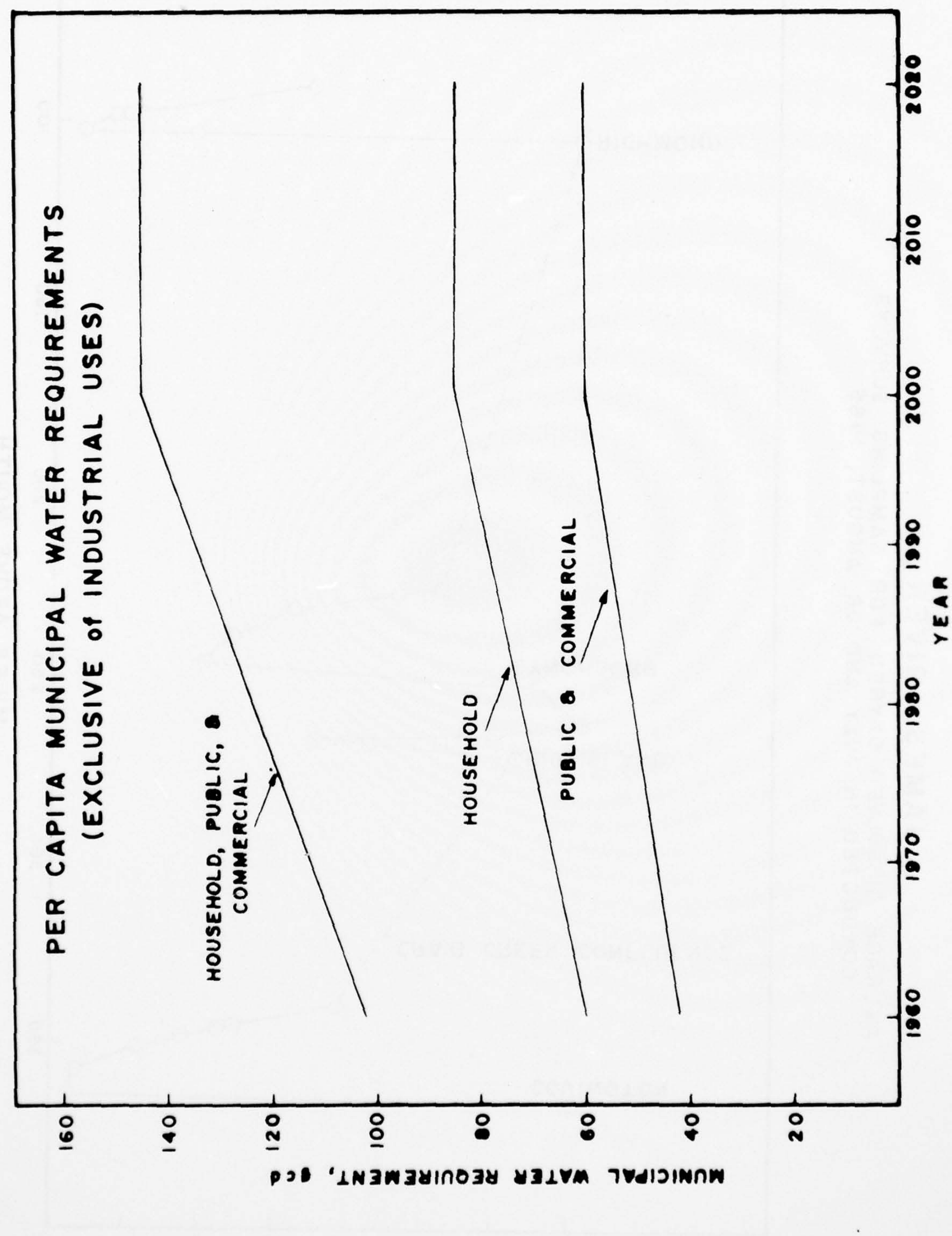

VALLEY
AND
RIDGE
BLUE RIDGE
PIEDMONT
COASTAL
PLAIN
LOCATION MAP
INDUSTRIAL WASTES
1 WEST VIRGINIA PULP & PAPER
2 JAMES LEE & SONS
3 OWENS ILLINOIS PAPER CO
4 MEAD PAPER CO
5 AMERICAN CYANAMID
6 E.I. DUPONT
7 ALLIED CHEMICAL, FIBERS DIV
8 ALLIED CHEMICAL, NITROGEN DIV
ALLIED CHEMICAL, NATIONAL ANNILINE DIV
9 CONTINENTAL CAN CO
10 HERCULES POWDER CO
MUNICIPAL WASTES
A CITY OF LYNCHBURG
B CITY OF RICHMOND
C CITY OF PETERSBURG
D LAMBERT POINT S.T.P. (H.R.S.D.)
E ARMY BASE S.T.P. (H.R.S.D.)
F BOAT HARBOR S.T.P. (H.R.S.D.)
G CITY OF PORTSMOUTH
LEGEND
1 INCH = 100,000 P.E.'s
INDUSTRIAL WASTE P.E.
MUNICIPAL WASTE P.E.
SECTION OF STREAM EXPERIENCING RECURRENT CONDITIONS OF LOW DO AND/OR EUTROPHIC CONDITIONS
INDUSTRIAL WASTES
MUNICIPAL WASTES
PROPOSED RESERVOIRS
VA
N.C.
APPALACHIA PROGRAM
WATER SUPPLY & WATER QUALITY CONTROL STUDY
JAMES RIVER BASIN
PRINCIPLE MUNICIPAL & INDUSTRIAL WASTE SOURCES
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
MIDDLE ATLANTIC REGION CHARLOTTESVILLE, VA.

Figure 1



PER CAPITA MUNICIPAL WATER REQUIREMENTS
(EXCLUSIVE of INDUSTRIAL USES)
HOUSEHOLD, PUBLIC, & COMMERCIAL
HOUSEHOLD
PUBLIC & COMMERCIAL
MUNICIPAL WATER REQUIREMENT, gcd
160
140
120
100
80
60
40
20
1960
1970
1980
1990
2000
2010
2020
YEAR

FIGURE 2

JAMES RIVER

AVERAGE DISSOLVED OXYGEN FOR SAMPLING SURVEYS
CONDUCTED IN JULY AND/OR AUGUST, 1966

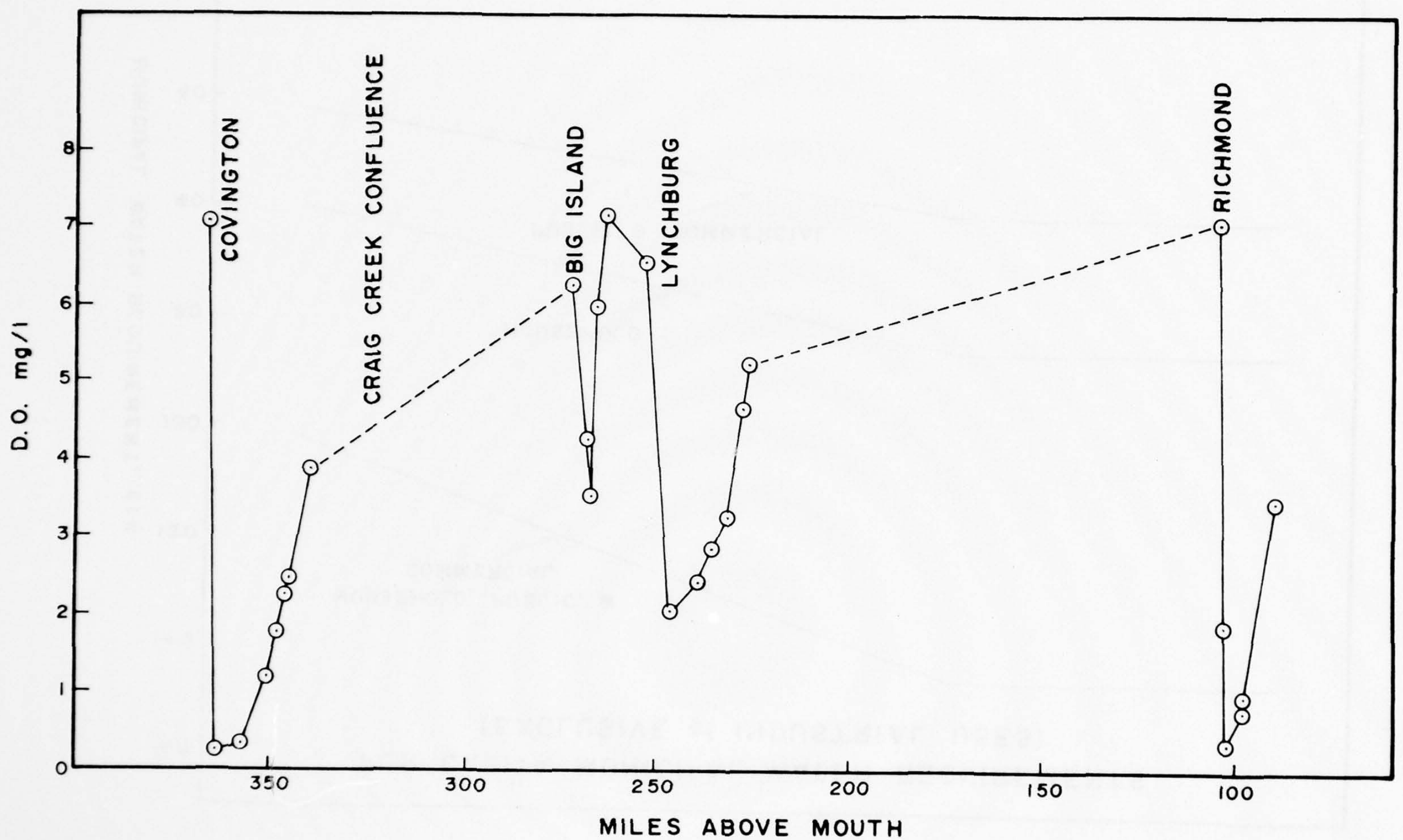


FIGURE 3

SIMPLIFIED SKETCH OF GEOMETRY
for
HYDROLOGIC ANALYSIS

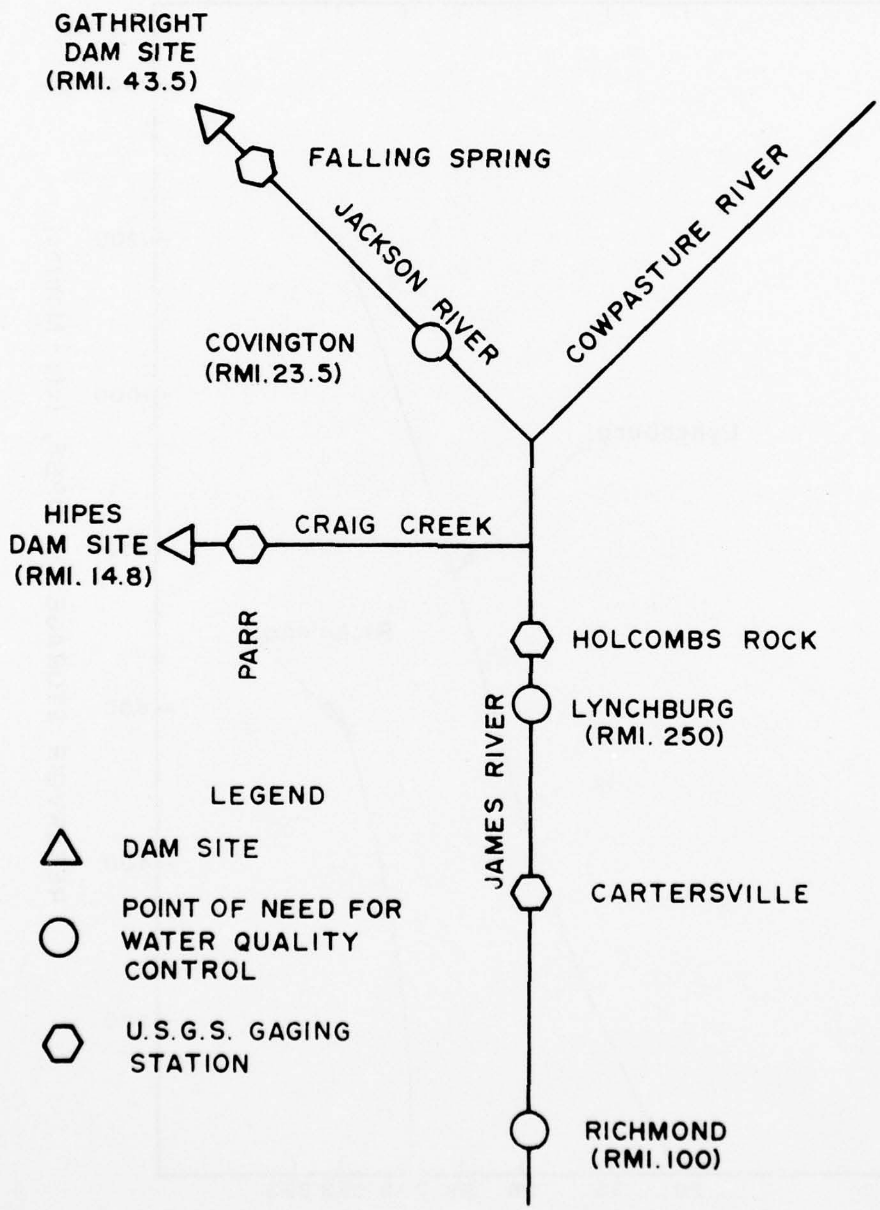


FIGURE I-B

RELIABILITY OF WATER QUALITY CONTROL VS. STORAGE FOR LOW FLOW AUGMENTATION

(ALTERNATE NO. 11 AT 2020 CONDITIONS)

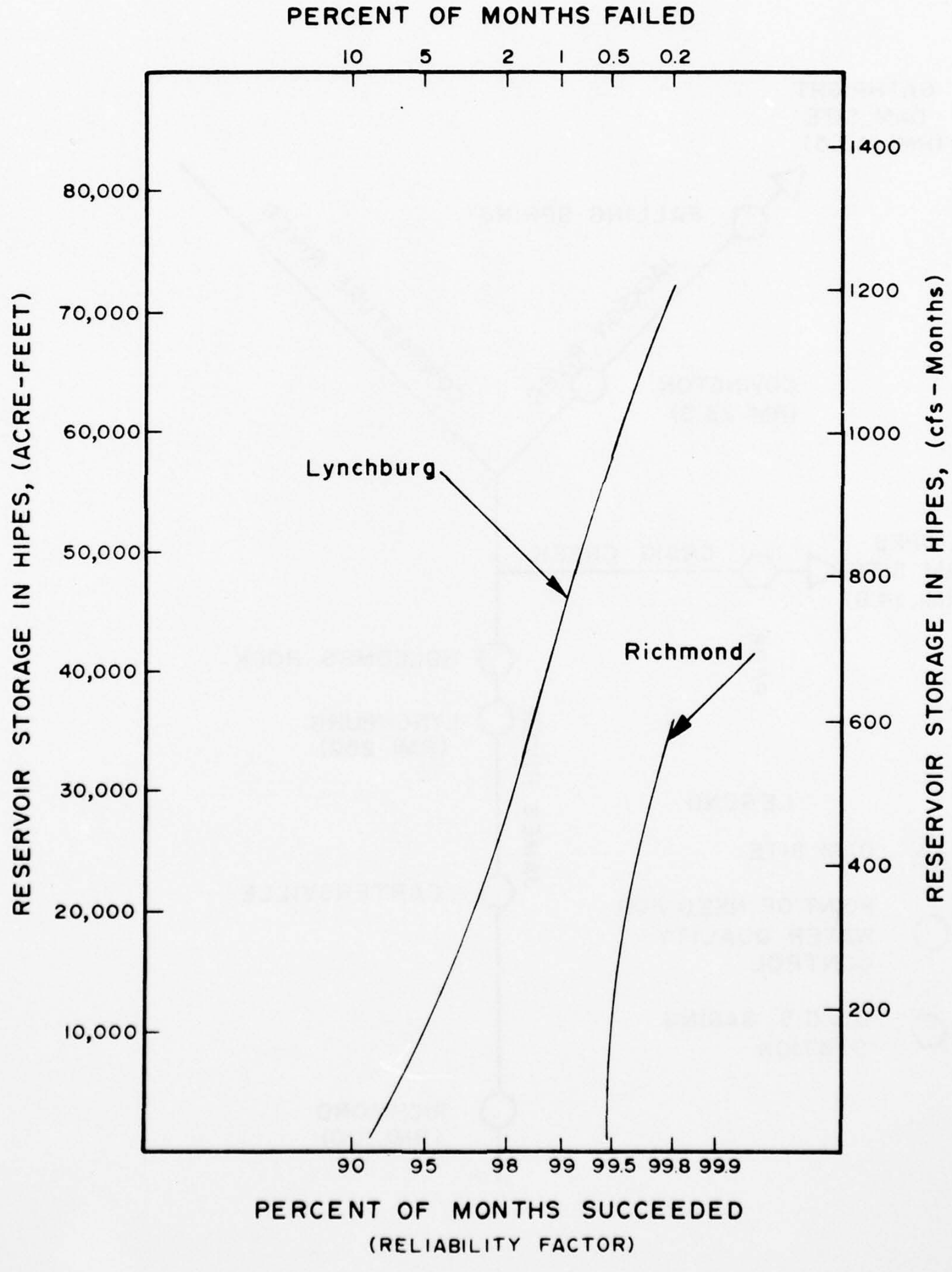


FIGURE 2-B

RELIABILITY OF WATER QUALITY CONTROL VS. STORAGE FOR LOW FLOW AUGMENTATION

(ALTERNATE NO. 11 AT 1995 CONDITIONS)

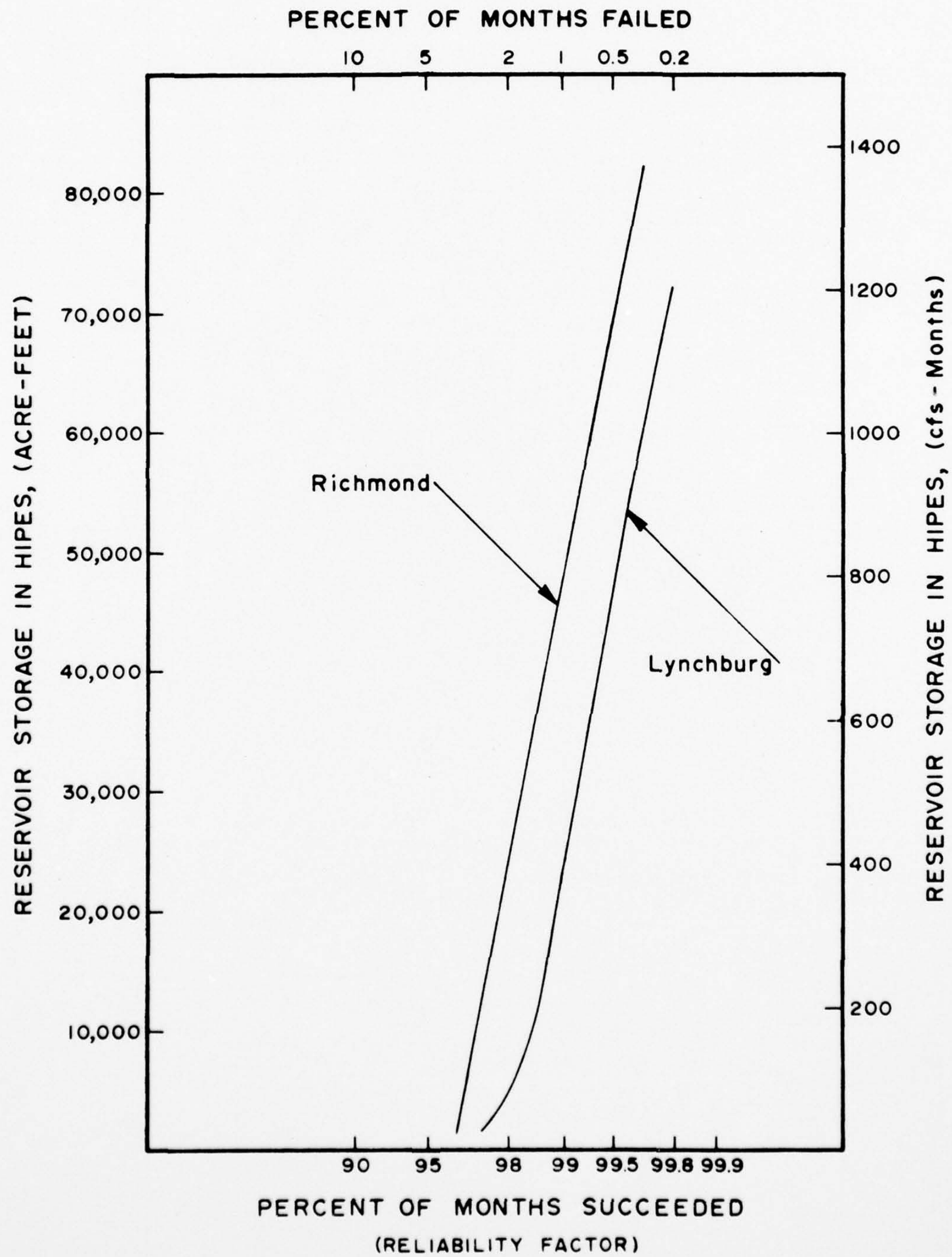


FIGURE 3-8

PART IV - SOUTHEAST REGION

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

Curry Creek Project

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Southeast Region
Atlanta, Georgia

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Mr. John W. Wakefield, Director
Comprehensive Programs, Southeast Region
Atlanta, Georgia

DATE: September 21, 1967

FROM : Chief, Reservoir Dynamics
Southeast Water Laboratory, Athens, Georgia

SUBJECT: Evaluation of Water Supply and Water Quality Control Needs, Curry Creek Project, Georgia

I. The Project

The proposed Corps of Engineers' reservoir project at the confluence of Curry Creek and the North Oconee River will be approximately 12 miles north of Athens, Georgia. All portions of the reservoir will be located in the central part of Jackson County, between and somewhat south of Jefferson and Commerce, Georgia. By Corps' standards the impoundment will be small, less than 6,000 acres in area at normal pool.

From a water supply and/or water quality control standpoint, there are three population centers which could be benefited by the project. These are: Jefferson, Commerce, and Athens-Clarke County.

II. Water Supply Benefits

Water supply needs were projected for the areas of urban influence of Jefferson, Commerce, and Athens. In Athens, the area to be served from a central water supply system was assumed to be all of Clarke County and portions of Jackson, Madison, Oglethorpe, and Oconee Counties.

Information on the existing water systems of the three urban centers may be detailed as follows:

System	Population Served	Average Water Production (mgd)	Source	Per Capita Use (gpd)	Remarks
Jefferson	2,200	0.50	Curry Creek	230	0.4 mgd for industry.
Commerce	3,800	0.75	North Oconee River and Turkey Creek	195	40% for industry.
Athens	50,000	6.03	North Oconee River and Sandy Creek	120	Two poultry plants only large industrial users.

Each of the above systems serve persons outside their respective municipal boundaries. There are no other large water users in the area of influence of the project with independent sources of supply.

A. Athens Water Supply Needs

By the year 2020, the Athens, Georgia, water system is projected to serve all of the 130,000 population projected for Clarke County plus portions of surrounding counties. Population in 2020 to be served outside Clarke County has been allocated as follows:

County	Percent to be Served	Population Served
Jackson	10	3071
Madison	10	1474
Oconee	30	3600
Oglethorpe	10	800

The total population to be served by the Athens system in 2020 is 139,000. At present, the per capita water use is 120 gallons per day. To account for projected growth of water-using industry, this figure is estimated to increase to 175 gpcd by 2020. Total water demand on the system, then, will be 24.3 mgd.

The dependable supply of water for Athens from the North Oconee River and Sandy Creek is approximately 17 mgd (based on low flow of record, i.e. 1955 drought). By 2020, upstream development is assumed to reduce this dependable supply to 15 mgd. Thus, an additional water source capable of yielding some 10 mgd will be needed to supply water during critical streamflow periods.

In order to evaluate the benefits which Athens might derive from water supply storage in the Curry Creek Reservoir, the least cost alternate for obtaining 10 mgd during dry weather periods was estimated. This cost was assumed equal to the benefits. A number of alternatives were considered. Included were (1) development of groundwater reserves (rejected for lack of adequate supply), (2) single-purpose reservoirs on nearby drainage areas (including at the proposed Curry Creek site), and (3) use of water from the Middle Oconee River. The latter alternative proved to be the least costly, and because the low flow of record on the Middle Oconee River at Athens is 17 mgd, the river would be a dependable water supply source.

The total capital cost to develop the Middle Oconee source would include intake, pump station, and transmission line to the treatment plant. This cost is estimated to be $464,000. The annual equivalent capital cost discounted from the time first needed would be $7,200. Annual operation and maintenance costs discounted to the present are estimated to be $800. The total annual benefit for water supply storage for Athens, then, has been estimated to be $8,000.

B. Jefferson Water Supply Needs

At present, the per capita water consumption in Jefferson is a very high 230 gallons per day. Water supplied for industrial use at Jefferson Mills is the reason for this high per capita figure. For the purpose of projection, it is assumed that the 230 gpcd rate will remain constant -- additional industry is not expected to increase this rate.

The Jefferson system presently serves about 12 percent of the Jackson County population. By 2020 it is expected to serve 15 percent. The total water demand will be 1.1 mgd (versus the present 0.5 mgd).

An analysis of the dependable supply which could be yielded from the Curry Creek watershed above the present water intake indicates that no more than 0.45 mgd can be expected during extreme dry weather periods. By 2020 then, an additional supply of up to 0.7 mgd would be needed during critical flow periods.

Another study of alternatives was made to evaluate water supply storage benefits. The most likely alternates were (1) development of single-purpose storage impoundments, or (2) use of water from nearby Middle Oconee River. Again, the development of intake, pump station, and transmission line from the Middle Oconee River proved to be the least costly. Total capital cost was estimated to be $137,000, which when converted to annual equivalent cost and discounted was determined to be $3,000. With a discounted operation and maintenance cost of $400, the total water supply storage benefits for Jefferson are estimated as $3,400 per year.

C. Commerce Water Supply Needs

The Commerce, Georgia, water supply system now serves about 21 percent of the Jackson County population. As shown previously, the per capita water use is a high 195 gallons per day (40 percent of supply for industry). If this consumption rate is maintained through the year 2020, and if 25 percent of the projected county population were to be served by the Commerce water system, a total demand of 1.5 mgd would result. Since the present source of supply is capable of yielding approximately 8 mgd during extreme dry weather periods, however, there would be no need for water supply storage in Curry Creek Reservoir.

D. Total Annual Water Supply Benefits

For the Athens-Clarke County area:	$8,000
For the Jefferson area:	$3,400
Total benefits:	$11,400

III. Water Quality Control Benefits

Water quality control releases from the Curry Creek Reservoir would be of potential benefit only to the Athens, Georgia, area. At present, the municipal and industrial waste generated in Athens enters both the Middle and North Oconee Rivers:

Waste Source	Type Treatment	Flow (mgd)	Receiving Stream
Treatment Plant #1	Secondary	3.8	N. Oconee River
Treatment Plant #2	Secondary	1.5	Middle Oconee River

No other major wastes sources are known to exist. The wastes discharged from the two municipal treatment plants eventually meet at the confluence of the Middle and North Oconee Rivers, approximately four miles southeast of Athens.

With 85 percent removal of 5-day biochemical oxygen demand (BOD_5), the present waste load entering the two streams is 1,440 lb/day BOD_5. By the year 2020 this load, from both municipal and industrial sources, is expected to be 4,250 lb/day after treatment. Not all of the wastes generated within Clarke County will be treated in the same two treatment plants. Some treated effluents will enter streams which could not and/or would not need to be influenced by water quality releases from Curry Creek Reservoir.

An analysis of flows needed to protect water quality in the North Oconee and Oconee Rivers below Athens was made. It was determined that a dissolved oxygen level of at least 4 mg/l was the most critical water quality indicator to maintain. Available flows from the North and Middle Oconee Rivers, even at the 7-day, once in ten-year minimum, were found to be adequate to maintain 4 mg/l dissolved oxygen. Under existing free-flowing stream conditions, the aeration from low head dams now in place below Athens would further benefit the maintenance of a minimum

dissolved oxygen level. If the stream were impounded below Athens by 2020, which is very probable, acceptable water quality should still obtain.

In conclusion, water supply storage in Curry Creek Reservoir would be of benefit by the year 2020, but there would not be a need for storage for water quality control purposes.

John A. Little

John A. Little

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

Dalton, Georgia, Coosa Navigation,
and North River Projects

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Southeast Region
Atlanta, Georgia

AD-A041 404 CORPS OF ENGINEERS CINCINNATI OHIO F/G 8/6
DEVELOPMENT OF WATER RESOURCES IN APPALACHIA. VOLUME 19. APPEND--ETC(U)
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C O P Y

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Southeast Region, Suite 300
1421 Peachtree Street, N.E., Atlanta, Georgia 30309

June 12, 1968

District Engineer
U.S. Army Engineer District, Mobile
P.O. Box 2288
Mobile, Alabama 36601

Attention: Mr. B.J. Christiansen

Dear Sir:

Subject: Report on Dalton, Georgia, Coosa Navigation, and North River Projects in accordance with Appalachia Plan of Survey and U.S. Corps requests.

We have concluded our study of the captioned projects and submit for your use in the current Appalachia study the following abbreviated report.

Dalton, Georgia

There will be a need for water in the Conasauga Basin in the area of Dalton, Georgia. The present source should become deficient by about 1980. Projected municipal and industrial water supply needs in this area are: 1980 - 29 mgd; 2000 - 64 mgd; and by year 2020 - 137 mgd. Because the Conasauga River, which serves portions of four counties in Georgia, has very limited low flows during extended dry periods, local interest presently envisions a complete change in source for future supply. As a consequence, any impoundment or impoundments such as proposed by the U.S. Corps of Engineers on the Conasauga River will accrue marked benefits for water stored for municipal and industrial purposes. The attached Exhibit II displays the annual values of these benefits.

There will also be a water quality problem in the Conasauga River below Dalton. Degradation of water quality, to the point of not being acceptable for warm water fish and many other beneficial uses, will occur in about 1980 despite the development of secondary waste treatment facilities at Dalton. Storage for quality maintenance is one abvious solution to this problem. The minimum flow needs to protect water quality through year 2020 at Dalton, Georgia, are shown on Exhibit I.

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North River Project

We understand from a 6 October discussion with Mr. Reid of your office that the North River Project lost local support and has been dropped from consideration as an Appalachia project. We, therefore, have no water supply or quality statement to make concerning this project.

Coosa Navigation Project

The only comment we have here concerns the proposed cutting of Mayo's Bar, an old, unused, partially destroyed lock in the Coosa River just west of Rome, Georgia. We discussed this problem with the Georgia State Water Quality Control Board and have concluded that for planning purposes no problems are foreseen in terms of water quality that would preclude the removal of Mayo's Bar. This conclusion is drawn from observations of existing conditions of water quality above and below the bar, together with the condition of the bar itself. Should this project receive favorable consideration and evolve to a final planning stage, we would like to make a more detailed study based on considerable field testing.

We believe this fulfills all detailed requests you have made to this data concerning the Appalachia survey. If you have further questions, please do not hesitate to call.

Sincerely yours,

John W. Wakefield

John W. Wakefield
Director, Comprehensive Planning
and Programs

Attachments (2)

cc: Mr. Fred Wampler w/attachments

DALTON, GA.

F.W.P.C.A.
ATLANTA
JUNE 1968

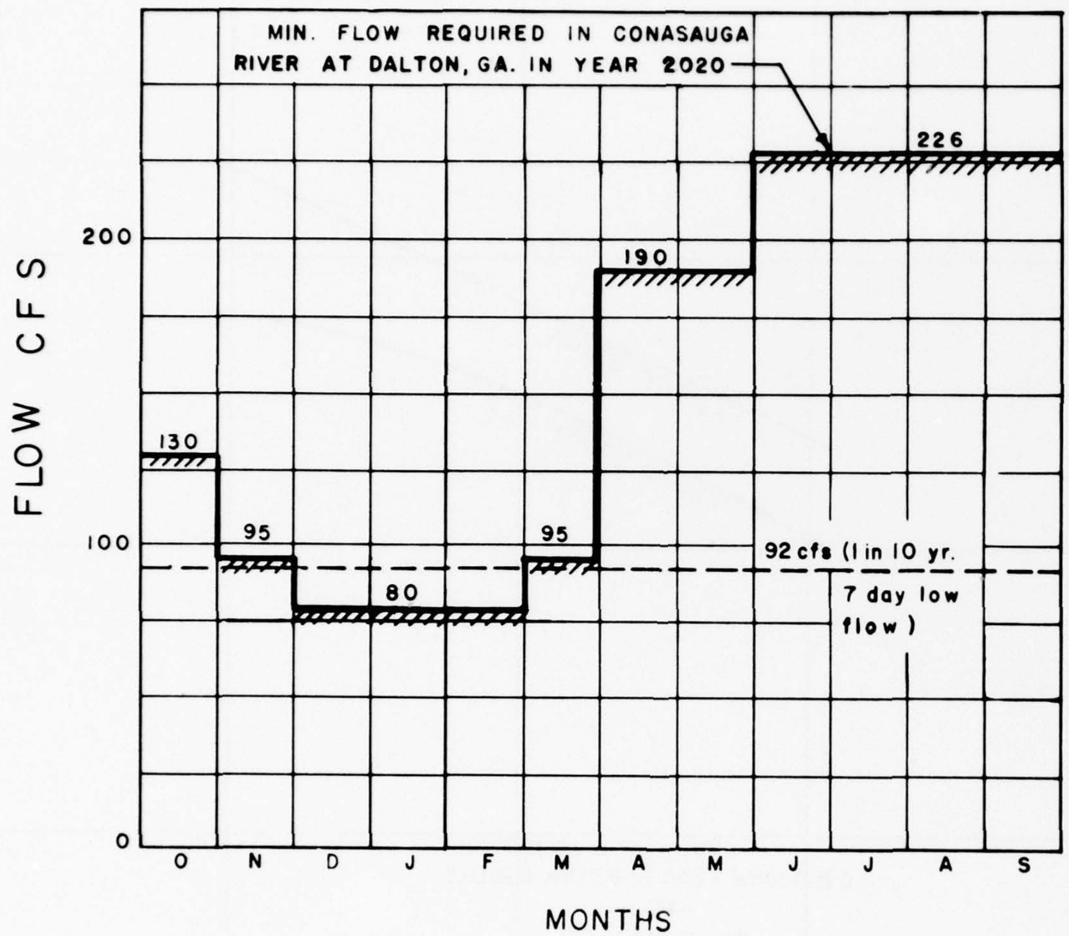

EXHIBIT I

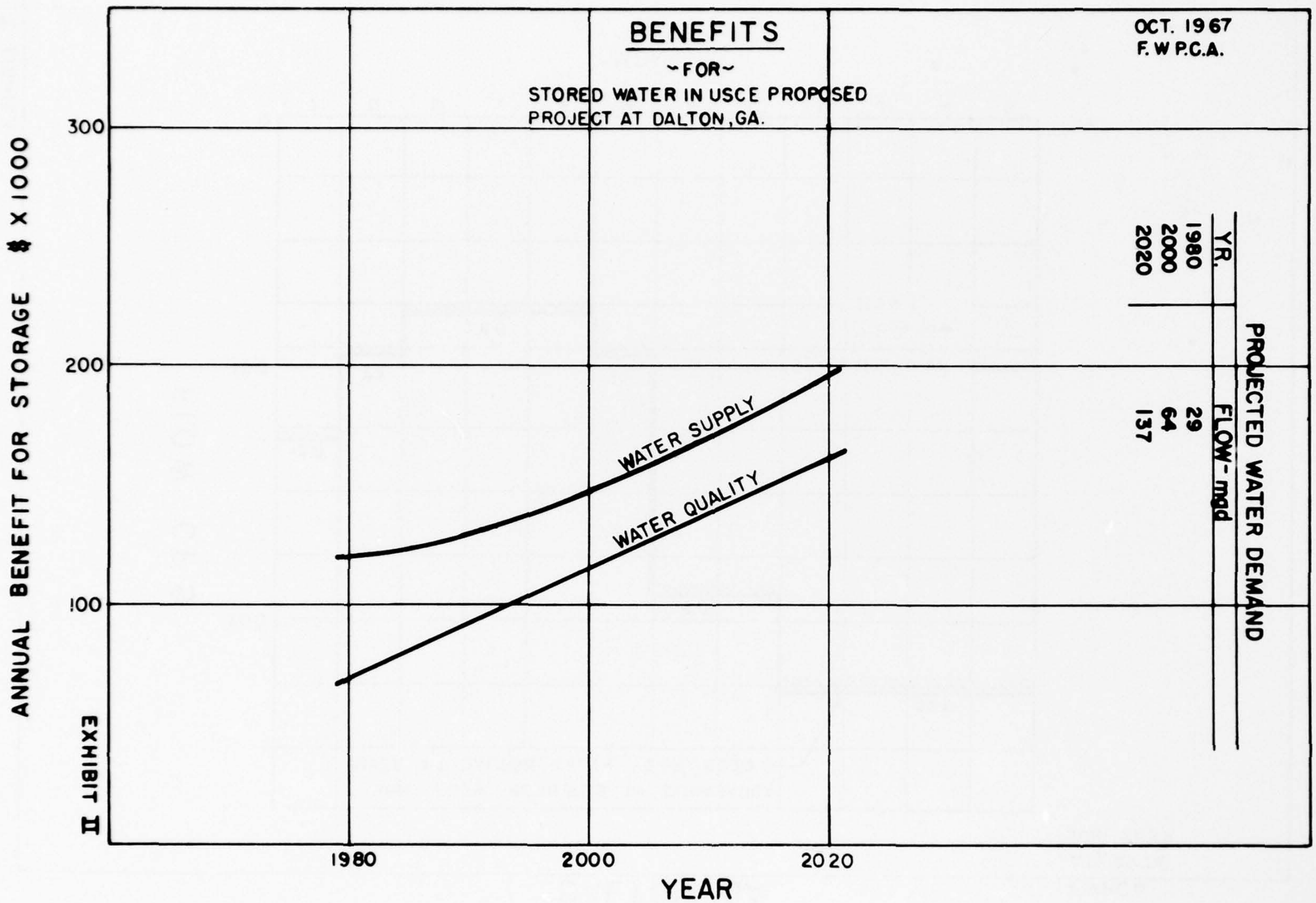
BENEFITS
~FOR~
STORED WATER IN USCE PROPOSED
PROJECT AT DALTON, GA.
OCT. 1967
F.W.P.C.A.
PROJECTED WATER DEMAND
YR.
FLOW - mgd
1980
29
2000
64
2020
137
WATER SUPPLY
WATER QUALITY
300
200
100
1980
2000
2020
YEAR
ANNUAL BENEFIT FOR STORAGE $ X 1000

EXHIBIT II

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL STUDY

French Broad River Basin Project

by

Tennessee Valley Authority
Knoxville, Tennessee

FRENCH BROAD RIVER PROJECT, NORTH CAROLINA

SUMMARY OF WATER QUALITY AND WATER SUPPLY PROVISIONS

Tennessee Valley Authority

As a part of its program of resource development for the Tennessee River basin, the Tennessee Valley Authority has developed a comprehensive plan for development of the water resources of the upper French Broad River basin in North Carolina. The plan for multiple-purpose development calls for a system of 14 dams, 74 miles of channel improvements, and 1.4 miles of levee at Asheville as shown on the accompanying map. The system would provide significant flood control benefits, as well as benefits from water quality control, water supply, recreation, shoreline development, fishing, and area redevelopment.

Water Quality Control

The existing industries in the French Broad River Basin were attracted to the area partly because of the abundance of clean, cold, clear water flowing out of the mountains. As the industries grew and as the population increased, some of the streams became polluted. In some stream reaches the color became objectionable and the dissolved oxygen content was so low that fish could not survive. In such stream reaches, there was no waste assimilative capacity left for new industries to use. Prior to the installation of corrective measures consisting of secondary treatment and chlorination as required by the North Carolina water pollution control regulatory agency, the untreated combined industrial and domestic wastes from the Asheville area (most of the Metropolitan Sewerage District of Buncombe County) added estimated waste loads to the French Broad and its tributaries equivalent to that of 199,000 people.

For many years, the main stem of the French Broad River between Davidson River and Mud Creek was one of the most polluted streams in the south. One large industrial plant, prior to the installation of pollution abatement measures, discharged untreated waste into this reach of the river having a high color and an estimated biochemical oxygen demand equivalent to the waste load from a population of 360,000 people. Under those conditions, during the low flow months, it was not uncommon for the dissolved oxygen level in several miles of the river between Davidson River and Mud Creek to be below 4 milligrams per liter (mg/l), dropping to zero at the low point of the oxygen sag. The

industry primarily responsible for this pollution problem has now made in-plant changes and constructed pollution abatement facilities substantially equivalent to secondary treatment in compliance with the requirements of the North Carolina water pollution control regulatory agency and is studying the need for additional pollution abatement facilities. For at least a few years following the construction of these and the other pollution abatement measures constructed or projected, the minimum dissolved oxygen level in the French Broad River downstream from the mouth of the Davidson River (river mile 190.6), during periods of natural low flow, would be about 4 mg/l. However, as time passes and treated waste loads increase due to normal industrial and population growth, particularly should benchmark goals be reached, dissolved oxygen concentrations would be expected to recede to lower levels.

In order to maintain the desired water quality level below the Davidson River for projected conditions, streamflow regulation utilizing 32,000 acre-feet of upstream storage will be required. This storage will assure a regulated minimum streamflow of 315 cfs and a dissolved oxygen level of at least 4 mg/l during 19 out of 20 years. This level of quality is necessary to maintain fish life in the stream and to meet TVA water quality objectives.

A second phase of the water quality control problem concerns plant nutrients. Existing and projected instream concentrations of nitrogen and phosphorus from sewage effluents and farm drainage must be reduced by waste treatment, where feasible, and by streamflow regulation to help avoid nuisance-level growths of benthic weeds in the French Broad River downstream from Asheville and of algae in Douglas Reservoir. The aquatic plant growing season generally is May through September; therefore, provisions will be made for releasing water during this period. With the planned reservoir system (including those headwater reservoirs providing storage for control of dissolved oxygen levels), a streamflow of 1,000 cfs can be maintained during the summer period at and below Newport, Tennessee, (French Broad River mile 77.5).

Further details of the water quality aspects of the water resource development plan for the French Broad River basin in North Carolina are contained in the TVA report, "Streamflow Regulation for Water Quality Control, Upper French Broad River Basin," August 1, 1967 (119 pages plus appendixes).

Water Supply

Rainfall in the upper French Broad River basin is generally well distributed throughout the year with averages between 37 and 60 inches over most of the area, but with 80 inches annually in the mountains bordering the southern end of the valley. However, periods of drought do occur from time to time which place limitations on present water usage and future water-oriented growth. At present the majority of the municipal systems rely upon surface water sources, although some small systems are supplied from ground water sources.

The water-using industries in the basin are presently concentrated around the Asheville area. Generally, the large water users have provided their own supplies, and the small users have connected to municipal systems. The average daily use varies with different industries. For example, the American Enka Corporation uses 18 mgd and Sayles Biltmore Bleachery uses 5 mgd. Use by other industries varies considerably, giving a 4-county total usage of approximately 45 mgd.

It is expected that future deficiencies in water supply will center largely in the Asheville-Hendersonville area, the expanding industrial corridor between the two cities, and in individual industrial complexes elsewhere in the basin. With the increase in use of modern conveniences, and allowing for light-industry growth, a water use rate of 200 gallons per capita per day for the year 2070 is judged to be a conservative figure for the area. Using this rate and the projected Asheville-Hendersonville water user population for 2070, the municipal demands are estimated to be 76.7 mgd, or 85,900 acre-feet annually. This alone is 11,500 acre-feet more than the current yield of the existing supply for this area. The overall plan of development is designed to provide for this shortage in municipal supply, and to provide additional storages amounting to 13,000 acre-feet for potential industrial usage in the upper French Broad River basin area.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

December 23, 1967

Dear Mr. Chairman:

My report on the potential impact on water quality of water resource development projects proposed by the Tennessee Valley Authority in the Upper French Broad River Basin, North Carolina, is enclosed. This report has been prepared in accordance with Section 6 of Executive Order 11288.

The projects proposed by the Tennessee Valley Authority promise a positive contribution to water quality management in this area.

As a related matter, I would like to point out that the Federal Water Pollution Control Administration is modifying its procedures for evaluating benefits from water quality management storage and release, as described in my letter of June 16, 1967, to the Water Resources Council. Now benefit analysis and cost allocation procedures have been instituted in this Department and I have recommended their adoption by the other water resource agencies. For the French Broad River Basin development this would involve:

1. Appraisal directly, rather than by least-cost alternative procedures, of the value of the benefits to water use of improved quality resulting from inclusion of storage for water quality management or other project purposes;

2. Provision for participation by non-Federal agencies in the costs of water quality management storage in accordance with cost-sharing procedures appropriate to each use.

We have appreciated this opportunity to assist your agency and have enjoyed a most cooperative relationship with your staff.

Sincerely yours,

Secretary of the Interior

Honorable Aubrey J. Wagner
Chairman, Tennessee Valley Authority
Washington, D.C. 20444

Enclosure
cc: Secy. Files
Secy. Reading Files
Asst. Sec. for WPC

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United States
Department of the Interior
Office of the Secretary

POTENTIAL IMPACT ON WATER QUALITY OF PROPOSED WATER RESOURCES DEVELOPMENT PROJECT

UPPER FRENCH BROAD RIVER BASIN, NORTH CAROLINA

Washington, D.C.
December 1967

POTENTIAL IMPACT ON WATER QUALITY OF

THE PROPOSED WATER RESOURCES DEVELOPMENT PROJECT

IN THE UPPER FRENCH BROAD RIVER BASIN, NORTH CAROLINA

In accord with the requirements of Section 6, Executive Order 11288, this report reviews the potential impact on water quality of plans for development of the water resources in the Upper French Broad River Basin, North Carolina, as proposed by the Tennessee Valley Authority in the following documents:

1. Development of the Water Resources of the French Broad River Basin in North Carolina, Condensed Planning Report No. 60-100 (TVA, September 1966).

2. Development of the Water Resources of the French Broad River Basin in North Carolina, Supplement to Project Planning Report No. 60-100 (TVA, September 1967).

3. Streamflow Regulation for Water Quality Control, Upper French Broad River Basin (TVA, August 1, 1967).

PROPOSED PLAN

The proposed plan provides for 14 dams and reservoirs, 74 miles of channel improvement and 1.4 miles of levees to serve the purposes of flood control, water supply, recreation, and water quality management. Provision is made for 76,900 acre-feet of storage in 10 of the 14 proposed reservoirs for water to be used in water quality management.

AREA

The population of the French Broad River Basin is projected to reach about 410,000 by 2020 and 560,000 by 2070. Based on the location of the area, the nature of the labor force, the natural resources available, and the continued expansion of the national economy, manufacturing activity and employment in the pulp and paper, synthetic fibers, canning, and textile industries is expected to increase. The tourist and recreational trade is also a fast growing segment in the economy of the area. For this reason, emphasis on maintenance and enhancement of water quality in this area at levels consistent with anticipated recreational use is considered reasonable.

WATER QUALITY STANDARDS

North Carolina filed its water quality standards and plan of implementation for interstate waters, which includes the French Broad River, in June 1967, in compliance with the Water Quality Act of 1965. These standards are still under negotiation between the State and Federal Water Pollution Control Administration. It is anticipated that the remaining questions will soon be settled and that approval can be expected in the early part of 1968. The water quality standards used by the Tennessee Valley Authority to prepare this plan are higher than those proposed by North Carolina and provide for enhancement of water quality to a DO level of 4 mg/l. Maintenance of a DO of at least 4 mg/l is considered reasonable and desirable considering the potential recreational use of the French Broad River.

IMPACT ON WATER QUALITY

French Broad River. Storage and controlled release of water from the proposed projects, in combination with well-operated secondary treatment, is expected to maintain acceptable dissolved oxygen level over 70 miles of the French Broad River over the project design period. We agree with the use of 90 percent BOD removal for well-operated secondary waste treatment plants as a basis for consideration of water quality management storage. The storage provided appears sufficient to prevent oxygen demanding materials in the effluents from treatment plants and other sources from reducing the dissolved oxygen level below 4 mg/l during critical streamflow and high temperature conditions in the foreseeable future.

Maintenance of higher sustained flows in the French Broad River will also reduce the concentration of nutrients in the river and in the headwaters of Douglas Reservoir. Excessive concentrations of plant nutrients from municipal and industrial sources may stimulate obnoxious algae blooms and nuisance growths of aquatic weeds even after secondary treatment. Proper use of water quality control releases can assist in controlling the effects of nutrients but is not expected to prevent problems without provision of treatment to remove nutrients.

Advanced waste treatment being developed by this Department could control the effects of waste discharges on the French Broad River. While more expensive than flow regulation in the French Broad River Basin at this time, it is anticipated that costs will be progressively reduced and that increased consideration will need to be given to advanced waste treatment, particularly for nutrient removal, as the next logical step in the management of water quality in the project area.

Proposed Reservoirs. Trout fishing is an important recreational use of the Upper French Broad River and its tributaries. The Tennessee Valley Authority project report indicates that of the 200 miles of streams stocked in 1966, 11 miles will be replaced by impoundments in the proposed plan. Trout fishing is expected to be available in four of the fourteen proposed reservoirs. Fishing opportunities should be enhanced by the addition of 6,700 acres of lake surface and 183 miles of shoreline.

Trout require cool water with a high dissolved oxygen content. Thus it is important to maintain a water quality to meet these needs in the reservoirs and in the releases downstream from the proposed reservoirs. Discharge of the stored water from the hypolimnion as proposed could strengthen the resistance to mixing. This may lower the hypolimnion DO level, increase surface water temperatures, and encourage the growth of warm water fish that would compete with the trout in the reservoirs and in the streams flowing into the reservoirs. Ommission of multiple-level outlets in the Tennessee Valley Authority design because of operational problems will reduce the operational flexibility to maintain water quality at the project.

CONTROL OF POLLUTION AT PROJECTS

Recreational facilities and areas associated with the proposed reservoir projects should be given special attention to prevent pollution. Waste from comfort stations at the parks, playgrounds and picnic areas should meet all local, State, and Federal standards for waste disposal. Particular attention should be given to the disposal of wastes so as to minimize their contribution to the eutrophication of the waters in the proposed reservoirs. Review of plans for recreational facilities as provided in Executive Order 11288 should be undertaken at the earliest practical time.

Special precautions should be taken to prevent pollution during the construction of the individual projects. Storage facilities for oils, greases, fuels or other similar materials capable of causing water pollution should be located to minimize the hazards to water pollution which might result from spills. Sanitary facilities should be provided for the construction personnel. Construction practices should be used that minimize silt pollution of waters at the construction site as well as at the borrow areas for the construction materials.

RECOMMENDATIONS

1. The nutrient levels in the French Broad River, even with flow regulation, appear to be high and eutrophication remains a possibility. Provision of storage and the regulation of flow for the maintenance of water quality is

considered supplementary to treatment. We believe that treatment to remove nutrients at the source will be needed as a step in a flexible water quality management program for the Upper French Broad River, to be realized after the program contemplated in the present Tennessee Valley Authority report. It is recommended that water quality conditions and available waste treatment facilities and costs be reviewed periodically with appropriate State and local authorities so that provisions can be made for additional treatment and for adjustment of operating schedules for basin reservoirs so as to make maximum contributions to the water quality standards upon which the Tennessee Valley Authority report is based.

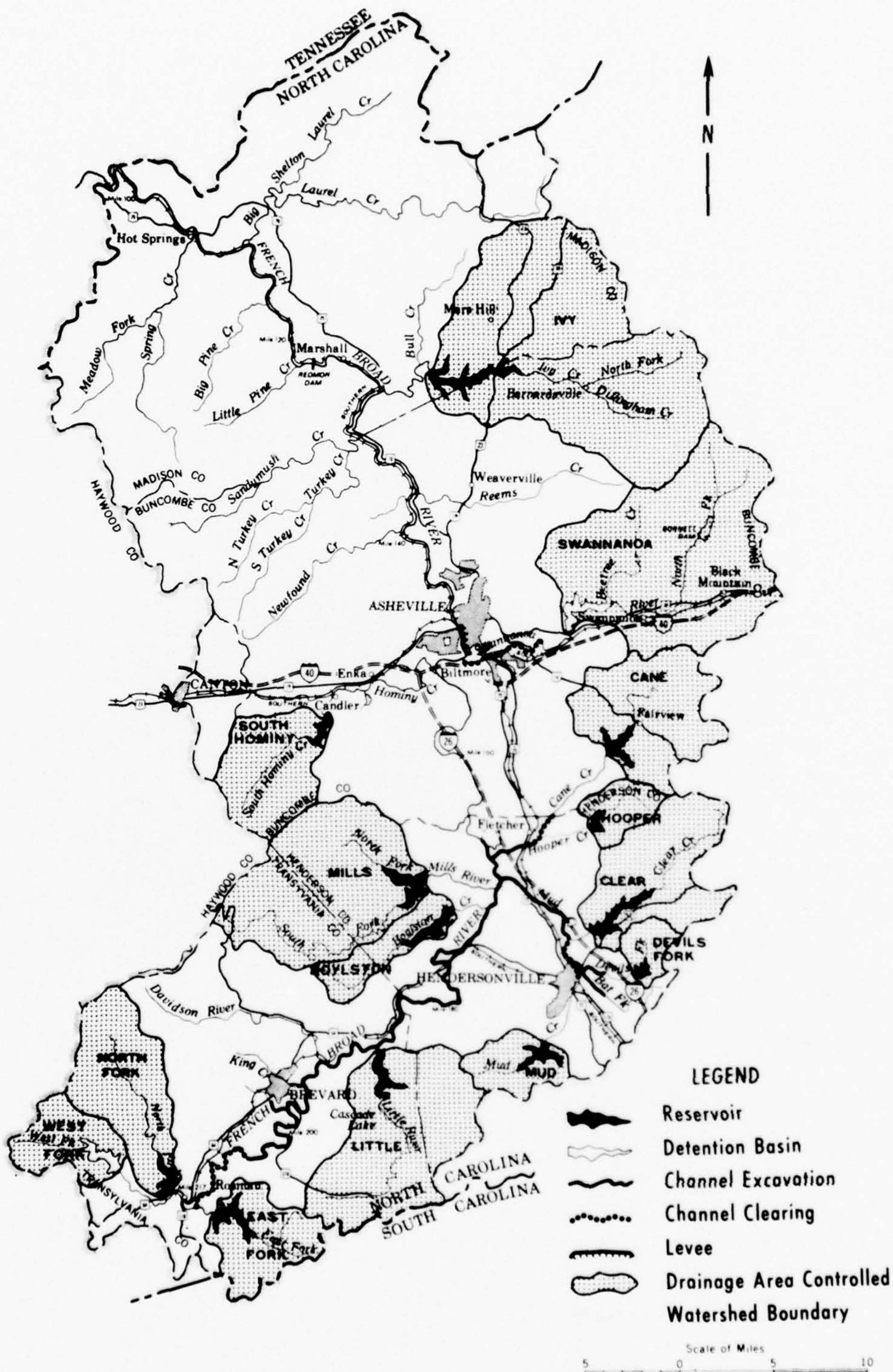
2. It is recommended the proposed reservoirs be cleared of all matter that would result in profundal pollution that could adversely affect the quality of water released. Trees and undergrowth should be cleared from the area to be inundated. Provision should also be made for any unusual pollution sources such as solid waste disposal sites, chemical deposit sites, and sanitary land fills.

3. As recreation areas associated with the reservoir projects are developed in the future, the plans for the proposed sanitary facilities should be submitted to the Federal Water Pollution Control Administration Southeast Region for review. This should be accomplished at the earliest feasible stage of plan development.

4. It is recommended that measures be taken to prevent pollution of surface and underground waters during construction of the projects.

5. Efficient operation of the proposed system of 14 dams and reservoirs to control and abate the effects of residual oxygen-demanding and plant-nutrient wastes will require information on the quality of the water in and below the proposed projects. For this reason, it is recommended that a program for regular collection of necessary water quality data be made a part of this project. As data becomes available, comparison should be made with the design parameters and adjustments made to obtain maximum water quality improvement under the prevailing conditions consistent with the project goals. The findings would be very helpful in appraising future water resource development projects.

6. Multiple level outlets would permit flexibility in management of temperature, dissolved oxygen, and other quality factors within and below the projects. It is recommended that further consideration be given to provision for multiple level release or for later addition of such facilities if observations of water quality indicates their desirability.



PLAN OF DEVELOPMENT
FOR THE FRENCH BROAD RIVER BASIN IN NORTH CAROLINA

POTENTIAL IMPACT ON WATER QUALITY OF PROPOSED YELLOW CREEK PORT PROJECT TENNESSEE RIVER BASIN, MISSISSIPPI

Southeast Region
Federal Water pollution Control Administration
U.S. Department of the Interior

December 1968

POTENTIAL IMPACT ON WATER QUALITY OF PROPOSED
YELLOW CREEK PORT PROJECT
TENNESSEE RIVER BASIN, MISSISSIPPI

The proposed port project would provide a terminal facility to store, load, and unload bulk cargo from barges of the type used in inland-river navigation and sites for future industrial plants with convenient access to the port terminal, to railroads, and to highways. The location of the proposed port is on Yellow Creek Embayment about three miles above its junction with the Tennessee River in Tishomigo County, Mississippi.

The Tennessee River is impounded by Pickwick Landing Dam downstream of Yellow Creek Embayment. Under existing flow conditions there is a slow movement of Yellow Creek water through the embayment into Pickwick Lake. Dry weather flow in Yellow Creek near Burnsville, Mississippi, has been recorded at less than 5.0 cfs. The 7-day, 10-year minimum flow of the Tennessee River at Savannah, Tennessee, below Pickwick Dam for the period of record is computed to be 17,500 cfs.

Pending water resource development in this area includes the already authorized and presently being designed, Tennessee-Tombigbee Waterway Navigation Project. This major inland-waterway development will provide the connecting link between the Tennessee River navigable waterway and the Lower Tombigbee River navigable waterway. The authorized project provides for a canal from Pickwick Reservoir through the divide between the Yellow Creek drainage basin and the drainage basin of the East Fork, Tombigbee River. The water level in the Yellow Creek canal will be that of Pickwick Reservoir through the divide to a 84 foot (normal pool elevation) lock and dam on East Fork, Tombigbee River near Bay Springs, Mississippi.

Assuming reasonably heavy navigation traffic, the discharge of water to operate the Bay Springs lock, having nominal dimensions of 110 feet by 600 feet, will cause flow of undetermined magnitude from Pickwick Reservoir into the headwaters of the Tombigbee River. During periods of light use the canal through the divide should have practically no movement.

The industrial development anticipated to result from the construction of rail, highway, and water transportation facilities in connection with the proposed port will probably include a substantial number of workers and a number of heavy water-use industries with resultant liquid wastes to be treated and discharged. The waters of Yellow Creek presently

are of high quality and the discharge of even highly treated effluent will result in some degradation. Further, the impounded embayment is relatively clear and any discharge of nutrients will stimulate the growth of algae and other aquatic vegetation.

It is apparent therefore that the discharge of normally treated industrial wastes and sewage into Yellow Creek should be restricted or prevented. The alternatives are to discharge normally treated effluents into the Tennessee River, thus taking advantage of the much greater minimum flows and constantly moving waters through Pickwick Reservoir, or to provide advanced waste treatment to reduce polluting constituents essentially to background levels.

An economic analysis to determine the least costly alternative to accomplish adequate water quality management can only be made after it is known what types of industrial processes are involved and their approximate output. Since these facts will be fully known only after the area is fully developed the more flexible plan to collect treated effluent for discharge into Pickwick Reservoir appears to be the preferable alternative.

The proposed port and the projected industrial sites are located two to five miles from Pickwick Reservoir. It is recommended that in planning the port facility provision should be made for utility easements or rights-of-way in which a waste collection system and a central pumping facility and forcemain can be installed to discharge treated effluent to Pickwick Reservoir. Space should also be available for treatment works in the event that it should become desirable to substitute public treatment works for individual works for each industry.

If public facilities are to be utilized a public agency with adequate authority must be responsible for planning, financing, construcing and operating the desired works. This could be achieved by an act of the Mississippi Legislature creating a special district for this purpose or one of several existing agencies could be employed. These include:

The Board of Supervisors, Tisomigo Coutny, Mississippi
The Tombigbee River Valley Water Management District
The Yellow Creek Watershed Authority

The Board of Supervisors, Tishomigo County, Mississippi and the Tombigbee River Valley Water Management District have the ability to assess taxes on the property in their respective areas of responsibility and to issue bonds supported thereby. The Yellow Creek Watershed Authority would have to seek a legislative act empowering them to levy taxes if they are to undertake such a project.

These comments are applicable to the proposal to develop the port under the existing conditions of water management, i.e., with Yellow Creek flowing into the Tennessee River and are even more applicable to conditions that will prevail after the Tennessee-Tombigbee Waterway is developed. Under these later conditions the needs for water quality management become of critical importance, Although there has been no appropriation for starting construction on the waterway project, the flow characteristics which will develop when the waterway project is operative should govern planning for water quality management.

PART V - OHIO BASIN REGION

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

CONEMAUGH RIVER BASIN

PENNSYLVANIA

prepared for

U. S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS-APPALACHIA STUDY
U. S. ARMY ENGINEER DISTRICT
PITTSBURGH, PENNSYLVANIA

by

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION
WHEELING FIELD STATION

November 1967

APPALACHIAN REGION WATER RESOURCES
DEVELOPMENT PROGRAM

Conemaugh River Basin

Pennsylvania

Framework Report for Water Supply
and
Water Quality Control

Request and Authority

In a letter dated March 3, 1967, the Pittsburgh District, U. S. Army Corps of Engineers, requested the Federal Water Pollution Control Administration, Wheeling Field Station, Ohio River Basin Project, to prepare a generalized framework report on the Conemaugh River basin. (See drainage area map.) The Conemaugh is a potential water development area in the Appalachian Region.

The authority to conduct this study is contained in the Appalachian Regional Development Act of 1965, PL 89-4, Section 206-C

Purpose and Scope

This study determines the general projected need of streamflow for water supply and water quality control in the Conemaugh River basin. These needs are based on population benchmarks that reflect the developmental effect of the Appalachian Program on the area. The report is generalized and is not intended to be used for authorization of water development projects at specific locations. It is intended that specific streamflow requirements given in this report be used to screen potential reservoir projects for more detailed evaluation in the future.

Rationale Utilized in this Study

This report evaluates the general municipal and industrial water supply and water quality control needs in terms of total streamflow requirements by the year 2020 in areas which will need additional storage to solve low flow problems. In analyzing potential problem areas, it was assumed that existing communities would grow at the same rate as indicated by their respective county population benchmark projections. Industrial water use and waste loads were based upon benchmark employment projections as disaggregated to the county level by the U. S. Army, Corps of Engineers, Pittsburgh District. Such projections were further distributed to stream reaches according to the location of present industrial establishments and to the apparent land availability adjacent to the major streams.

The streamflow needs given in the tables do not necessarily agree with needs given in other reports prepared by Federal Water Pollution Control Administration because of the use of different economic projection data.

DESCRIPTION OF EXISTING CONDITIONS AND UTILIZATION

(1) Water Supply

The following municipalities have their public water supply sources in the Conemaugh River basin:

COUNTY	MUNICIPALITY	POPULATION SERVED	SOURCE OF SUPPLY	SAFE YIELD* (MGD)*	PRESENT USE (MGD)
Westmoreland	Derry, Pa.	5,000	McGee Run	S-5	
Indiana	Indiana, Pa.	16,500	Two Lick Cr. Ramsey Run	5.1	1.8
Indiana	Blairsville, Pa.	5,400	Hillside Run Reservoir	0.13 S-40	0.48
Indiana	Homer City, Pa.	2,471	Yellow Creek	0.62	0.45
Indiana	Clymer, Pa.	2,500	2 wells	0.3	0.20
Somerset	Windber, Pa.	15,000	Clear Shade Reservoir Piney Run Reservoir	4.6 S-75	0.90
Somerset	Central City, Pa.	3,000	Beaver Dam Run	1.0	0.16
Cambria	Johnstown, Pa.	62,500	5 reservoirs	6.6 S-2300	12.0
Cambria	Nanty-Glo, Pa.	6,000	Williams Run Reservoir	S-225	0.65
Cambria	Ebensburg, Pa.	8,000	N.Br. Little Conemaugh Reservoir	0.9 S-405	0.65
Cambria	Portage,Pa.	6,200	Trout Run Reservoir	0.1 S-100	0.40
Cambria	Geistown	3,186	7 reservoirs	S-274	Est.0.32

*For surface-water sources, this is taken to be the 1-day-30 year low flow; (S-Present impoundment capacity in million gallons.)
For ground-water sources, this is the total reliable yield.

(2) Water Quality Control

Municipalities that have sewerage facilities discharging into the drainage of the Conemaugh River basin are as follows:

COUNTY	MUNICIPALITY	POPULATION SERVED	RECEIVING STREAM	PRESENT TYPE TREATMENT*	LOW FLOW** (cfs)
Cambria	Johnstown, Pa.	81,500	Conemaugh River	P-C	152.
Cambria	Ebensburg, Pa.	7,500	Howell's Run	S-C	0.1
Cambria	Cresson, Pa.	3,000	Little Conemaugh Creek	None	0.0
Cambria	Nanty Glo, Pa.		Blacklick Creek	None	0.3
Westmoreland	Derry, Pa.	4,500	McGee Run	S-C	3.0
Indiana	Blairsville, Pa.	4,900	Conemaugh River	P-C	207.
Indiana	Indiana, Pa.	16,500	Two Lick Creek	None	7.
Somerset	Windber, Pa.	7,500	Paint Creek	None	9

* S - Secondary, P - Primary, C - Chlorination.
** 7 consecutive day once in 10-year frequency.

ANTICIPATED FUTURE CONDITIONS

(1) Water Supply

The following tables show projected total streamflow requirements by the year 2020 for municipal water supply where a low flow problem will exist. These flow needs are based on the U. S. Army Corps of Engineers' developmental benchmark projections.

Municipal Water Needs

COUNTY	AREA	PROJECTED TOTAL WATER SUPPLY REQUIREMENT 2020 (MGD)
Indiana	Indiana, Pa.	12.3
Indiana	Homer City, Pa.	2.7
Indiana	Clymer, Pa.	1.3
Westmoreland	Derry, Pa.	1.7
Indiana	Blairsville, Pa.	3.7

The community of Indiana, Pennsylvania, obtains its water supply from Two Lick Creek and Ramsey Run which are limited in quantity and are presently degraded from acid mine drainage. A reservoir located on Yellow Creek could supply the anticipated future demands of this area; however, this would require a reallocation of project purposes since it is operated at present solely for recreational purposes. Water quality at this site would be more acceptable for municipal uses than the existing source. (See page 6 for discussion of water quality.)

(2) Water Quality Control

The following table shows projected total streamflow requirements by the year 2020, for water quality control to assimilate municipal and industrial wastes where a low flow problem will exist. The flow needs are based on the benchmark projections:

Municipal and Industrial Wastes (Water Quality Control Needs)

COUNTY	AREA	RECEIVING STREAM	PROJECTED TOTAL STREAMFLOW REQUIRED 2020 (cfs)
Cambria	Ebensburg, Pa.	Howells Run	7
Cambria	Cresson, Pa.	Little Conemaugh River	3
Cambria	Nanty Glo	Blacklick Creek	5
Westmoreland	Derry, Pa.	McGee Run	8
Indiana	Indiana, Pa.	Two Lick Creek	97
Somerset	Windber, Pa.	Paint Creek	17

WATER QUALITY OF POTENTIAL RESERVOIR SITES

The following is a preliminary evaluation of the water quality characteristics of potential reservoir sites in the Conemaugh River basin:

1. Yellow Creek

Water quality reservoir site with good potential. The Pennsylvania Department of Forests and Waters reports that this site is being constructed, solely as a recreational facility. The stream (3 samples) had a pH of 6.8-7.2, conductance of 260-325 umhos/cm, dissolved oxygen of 7.2-7.7 mg/l, acidity of 5-8 mg/l, alkalinity of 23-29 mg/l, hardness of 102-285 mg/l, sulfate of 80-135 mg/l, total iron of 0.0-0.2 mg/l, manganese of 0.0-0.2 mg/l, aluminum of 0.0-0.4 mg/l, chloride of 608 mg/l, BOD_5 of 0.6-1.0 mg/l, fecal coliform of 70-210/100 ml, and fecal streptococci of 290-1000/100 ml. The bottom fauna was dominated by varieties typical of an unpolluted habitat.

2. Stony Creek

A. Ben's Creek

This is a good quality water. Presently, there is the North Fork Reservoir (3,870 acre-feet) and the Dalton Run Reservoir (403 acre-feet) owned by the Greater Johnstown Water Authority located on this stream. Possible flooding of these existing reservoirs should be considered

since it would require filtration of the impounded water for municipal water use. The stream (3 samples) had a pH range of 7.0-7.3, conductance of 560-630 umhos/cm, dissolved oxygen of 8.7-10.0 mg/l, acidity of 10-25 mg/l, alkalinity of 13-21 mg/l, hardness of 264-334 mg/l, sulfate of 255-350 mg/l, iron of 0.7-1.0 mg/l, manganese of 0.3-0.4 mg/l, aluminum of 0.3-3.6 mg/l, chloride of 2-3 mg/l, BOD_5 of 0.6-1.3, fecal coliform of 160-500 mg/l, and fecal steptococci of 110-250 mg/l. The substrate was covered with an orange precipitate and some intolerant bottom fauna existed.

B. Upper Stony Creek

This is a good potential water quality reservoir site. The stream (3 samples) had a pH range of 6.9-7.0, conductance of 490-520 umhos/cm, dissolved oxygen of 7.5/8.0 mg/l, acidity of 5-16 mg/l, alkalinity of 22-28 mg/l, hardness of 209-237 mg/l, sulfate of 174-475 mg/l, iron of 0.03 mg/l, manganese of 0.2-0.3 mg/l, aluminum of 0-1.0 mg/l, chloride of 11-20 mg/l, BOD_5 of 0.5-1.5 mg/l, fecal coliform of 3,200-98,000/100 ml, and fecal streptococci of 460-5,700/100 ml. The bottom fauna was dominated by pollution tolerant forms, probably caused by domestic pollution. Proper treatment would eliminate this problem.

3. Clear Shade Creek

This is excellent quality water. Presently, there are two public water supply reservoirs owned by the Richland Township Water Company about 0.3 miles above the site. Flooding of these existing impoundments by a new reservoir may require the water company to provide additional treatment. The stream (3 samples) had a pH range of 6.6-7.8, conductance less than 50 umhos/cm, dissolved oxygen of 7.4-9.1 mg/l, acidity of 6-10 mg/l, alkalinity of 5-10 mg/l, hardness of 7-48 mg/l,sulfate of 7-20 mg/l, iron of 0.0-0.1 mg/l, manganese of 0.0-2.2 mg/l, aluminum of 0.0 mg/l, chloride of 0-3 mg/l, 5-day BOD of 0.3-1.2 mg/l, fecal coliform of 10/100 ml, and fecal streptococci of 60-300/100 ml. The aquatic life was dominated by pollution intolerant organisms.

4. Tub Mill Creek

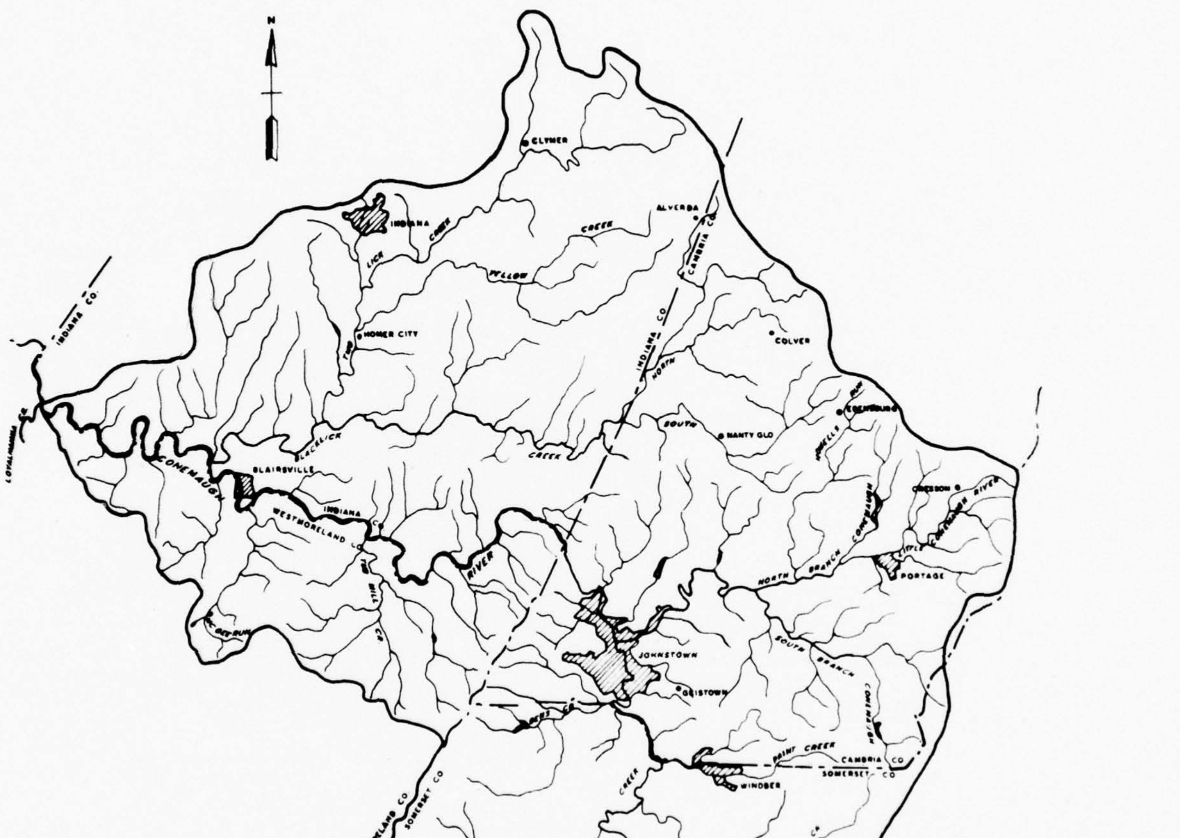
The potential reservoir site has good quality water. However, Tub Mill Creek receives some acid mine drainage downstream from the reservoir site. An abandoned mine about 1,000 feet downstream discharges a highly acidic load which decreases the stream pH to about 3.8. A more intensive investigation might determine that the location of the dam should be below the mine opening with subsequent flooding of the mine. The stream (3 samples) above the acid mine drainage had a pH range of 6.0-6.8, and an alkalinity of 2-16 mg/l. A variety of intolerant organisms and fish were observed.

MINE DRAINAGE EFFECTS ON QUALITY OF WATER

The most damaging and widespread water pollution problem in the basin is acid mine drainage from active and abandoned coal mining operations, both surface and underground. Low flow regulation is expected to be necessary for water quality control of the extreme acid character of some streams.

Following is a list of areas in the basin which are polluted and severely degraded by mine drainage:

(A)	Little Conemaugh River	Acidity (Avg. 51,000 lb/day). pH (3.0-4.2), iron, manganese, sulfates, hardness.
(B)	Stony Creek Drainage	Acidity, pH, iron, manganese, sulfates, hardness.
(C)	Conemaugh River from Johnstown, Pennsylvania to Loyalhanna Creek	Acidity (Avg. 208,000 lb/day). pH (5.4-6.8) iron (220), manganese (30.), sulfate (590), hardness (260).
(D)	Blacklick Creek	Acidity (Avg. 416,000 lbs/day). pH (2.5-2.9), iron (94), manganese (4.), sulfate (520), hardness (250).



LOCATION MAP

CONEMAUGH RIVER BASIN

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION WHEELING FIELD STATION

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

TYGART VALLEY RIVER BASIN

WEST VIRGINIA

prepared for

U. S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS-APPALACHIA STUDY
U. S. ARMY ENGINEER DISTRICT
PITTSBURGH, PENNSYLVANIA

by

U . S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION
WHEELING FIELD STATION

November 1967

APPALACHIAN REGION WATER RESOURCES
DEVELOPMENT PROGRAM

Tygart Valley River Basin

West Virginia

Framework Report for Water Supply
and
Water Quality Control

Request and Authority

In a letter dated March 3, 1967, the Pittsburgh District, U. S. Army Corps of Engineers, requested the Federal Water Pollution Control Administration, Wheeling Field Station, Ohio River Basin Project, to prepare a generalized framework report on the Tygart Valley River basin. (See drainage area map.) The Tygart Valley River is a potential water development area in the Appalachian Region.

The authority to conduct this study is contained in the Appalachian Regional Development Act of 1965, PL 89-4, Section 206-C.

Purpose and Scope

This study determines the general projected need of streamflow for water supply and water quality control in the Tygart Valley River basin. These needs are based on population benchmarks that reflect the developmental effect of the Appalachian Program on the area. The report is generalized and is not intended to be utilized for authorization of water development projects at specific locations. It is intended that specific streamflow requirements given in this report be used to screen potential reservoir projects for more detailed evaluation in the future.

Rationale Utilized in this Study

This report evaluates the general municipal and industrial water supply and water quality control needs in terms of total streamflow requirements by the year 2020 in areas which will need additional storage to solve low flow problems. In analyzing potential problem areas, it was assumed that existing communities would grow at the same rate as indicated by their respective county population benchmark projections. Industrial water use and waste loads were based upon benchmark employment projections as disaggregated to the county level by the U. S. Army Corps of Engineers, Pittsburgh District. Such projections were further distributed to stream reaches according to the location of present industries and to the apparent land availability adjacent to the major streams.

The streamflow needs given in the tables do not necessarily agree with needs given in other reports prepared by Federal Water Pollution Control Administration because of the use of different economic projection data.

DESCRIPTION OF EXISTING CONDITIONS AND UTILIZATION

(1) Water Supply

The following municipalities have their public water supply sources in the Tygart Valley River basin:

COUNTY	MUNICIPALITY	POPULATION SERVED	SOURCE OF SUPPLY	SAFE YIELD* (MGD)	PRESENT USE (MGD)
Randolph	Elkins, W.Va.	9,500	Tygart Valley River	0.6	1.3
Upshur	Buckhannon, W.Va.	7,350	Buckhannon River	0.15	0.7
Taylor	Grafton, W. Va.	10,000	Tygart Valley River	70.0	2.0
Marion	Fairmont, W. Va.	50,000	Tygart Valley River	81.3	7.2
Marion	Monongah, W. Va.	14,000	Tygart Valley River	80.7	0.9
Barbour	Philippi, W. Va.	2,700	Tygart Valley River	1.7	0.25

*For surface-water sources, this is taken to be the 1-day-30 year low flow. For ground-water sources, this is the total reliable yield.

(2)b Water Quality Control

Municipalities that have sewerage facilities discharging into the drainage of the Tygart Valley River basin are as follows:

COUNTY	MUNICIPALITY	POPULATION SERVED	RECEIVING STREAM	PRESENT TYPE TREATMENT	LOW FLOW** (cfs)
Randolph	Elkins, W. Va.	8,135	Tygart Valley River	S-C	1.7
Upshur	Buckhannon, W.Va.	4,450	Buckhannon River	S-C	1.6
Taylor	Grafton, W.Va.	7,430	Tygart Valley River	None	170***
Barbour	Philippi, W.Va.	2,800	Tygart Valley River	P-C	8.9

*S - Secondary, P - Primary, C - Chlorination

** 7 consecutive day once in 10-year frequency

*** Unadjusted with Tygart reservoir in place.

ANTICIPATED FUTURE CONDITIONS

(1) Water Supply

The following table shows projected total streamflow requirements by the year 2020 for municipal water supply where a low flow problem will exist. The flow needs are based on the U. S. Army Corps of Engineers' developmental benchmark projections.

MUNICIPAL WATER NEEDS - Tygart Valley River Basin

COUNTY	AREA	PROJECTED TOTAL WATER SUPPLY REQUIREMENT -2020 (MGD)
Randolph	Elkins, West Virginia	1.8
Upshur	Buckhannon, West Virginia	2.5

(2) Water Quality Control

The following table shows projected total streamflow requirements by the year 2020, for water quality control to assimilate municipal and industrial wastes where a low flow problem will exist. The flow needs are based on the benchmark projections:

Municipal and Industrial Wastes (Water Quality Control Needs)

COUNTY	AREA	RECEIVING STREAM	TOTAL STREAMFLOW REQUIRED -- 2020 (cfs)
Randolph	Elkins, W. Va.	Tygart Valley River	14
Upshur	Buckhannon, W.Va.	Buckhannon River	14
Barbour	Philippi, W.Va.	Tygart Valley River	15

WATER QUALITY OF POTENTIAL RESERVOIR SITES

The following is a preliminary evaluation of water quality characteristics of potential reservoir sites in the Tygart Valley River basin:

1. Teter Creek

An excellent water quality reservoir site. The stream (2 samples) had pH values of 7.3 and 7.7, conductance values of 115 and 120 umhos/cm, dissolved oxygen of 8.8 mg/l, acidity of 2 and 8 mg/l, alkalinity of 38 and 39 mg/l, hardness of 44 and 46 mg/l, sulfates of 20 mg/l, iron 0.1 mg/l, manganese of 0 mg/l, aluminum of 0.0 and 0.3 mg/l, chlorides of 3 and 4 mg/l, 5 day BOD of 0.7 and 1.5 mg/l, fecal coliform of 550 and 890/100 ml, and fecal streptococci of 380 and 850/100 ml. The bottom fauna consisted of a well-rounded invertebrate population.

2. Laurel Creek

A water quality reservoir site with good potential. The stream (6 samples) had a pH range of 6.7-7.4, conductance of 70-160 umhos/cm, dissolved oxygen of 6.4-13.4 mg/l, acidity of 4-26 mg/l, alkalinity of 5-46 mg/l, hardness of 26-73 mg/l, manganese of 0.0-0.6 mg/l, sulfates of 16-75, mg/l, chlorides of 0-2 mg/l, 5 day BOD of 0.3-1.6 mg/l, iron of 0.0-0.3 mg/l, total coliform of 270-7,400/100 ml, fecal coliform of 10-52/100 ml, and fecal streptococci of 42-290/100 ml. A variety of organisms representing an unpolluted condition was found.

3. Buckhannon River (French Creek above Gould, West Virginia).

An excellent water quality reservoir site. The stream (2 samples) had pH values of 7.4 and 7.8, conductance values of 110 and 120 umhos/cm, dissolved oxygen of 7.1 and 7.7 mg/l, acidity of 0 and 7 mg/l, alkalinity of 14 and 18 mg/l, hardness of 27 and 32 mg/l, sulfates of 20 and 25 mg/l, iron of 0.7 and 0.9 mg/l, manganese of 0.2 mg/l, aluminum of 0.1 and 1.0 mg/l, chloride of 10 and 11 mg/l, 5 day BOD of 1.2 and 1.7 mg/l, fecal coliform of 100 and 540/100 ml and fecal streptococci of 150 and 300/100 ml. The bottom fauna at this station was cominated by forms of intermediate tolerance. The substrate was mostly sand and not conductive to production of aquatic organisms.

4. Middle Fork River (Right Fork)

A water quality reservoir site with good potential. The stream (2 samples) had pH values of 7.6 and 7.9 conductance values of < 50 and 65, dissolved oxygen of 7.8 and 8.3 mg/l, acidity of 8 and 10 mg/l, alkalinity of 8 and 10 mg/l, hardness of 14 mg/l, sulfates of 10 mg/l, iron of 0.5 and 0.7 mg/l, manganese of 0 and 0.5 mg/l, aluminum of 0.7 and 0.8 mg/l, chloride of 1 and 2 mg/l, 5 day BOD of 0.6 and 1.3 mg/l, fecal coliform of 10 and 140 mg/100 ml, and fecal streptococci of 150 and 500/100 ml. A variety of organisms consisting mostly of intolerant forms were observed. This location supports low numbers of organisms, probably because of low fertility.

5. Upper Tygart River (Above Lee Bell).

An excellent water quality reservoir site. The stream (3 samples) had a pH range of 7.7-7.9, conductance of 120 umhos/cm, dissolved oxygen of 9.4-9.8 mg/l, acidity of 0-5 mg/l, alkalinity of 43-44 mg/l, hardness of 46-56 mg/l, sulfates of 10 mg/l, iron of 0.1-0.3 mg/l, manganese of 0-0.8 mg/l, aluminum of 0.3-0.8 mg/l, chlorides of 1-2 mg/l, 5 day BOD of 0.8-0.9 mg/l, fecal coliform of 10/100 ml and fecal streptococci of 120-190/100 ml. The bottom fauna was varied and abundant. It was typical of an unpolluted habitat.

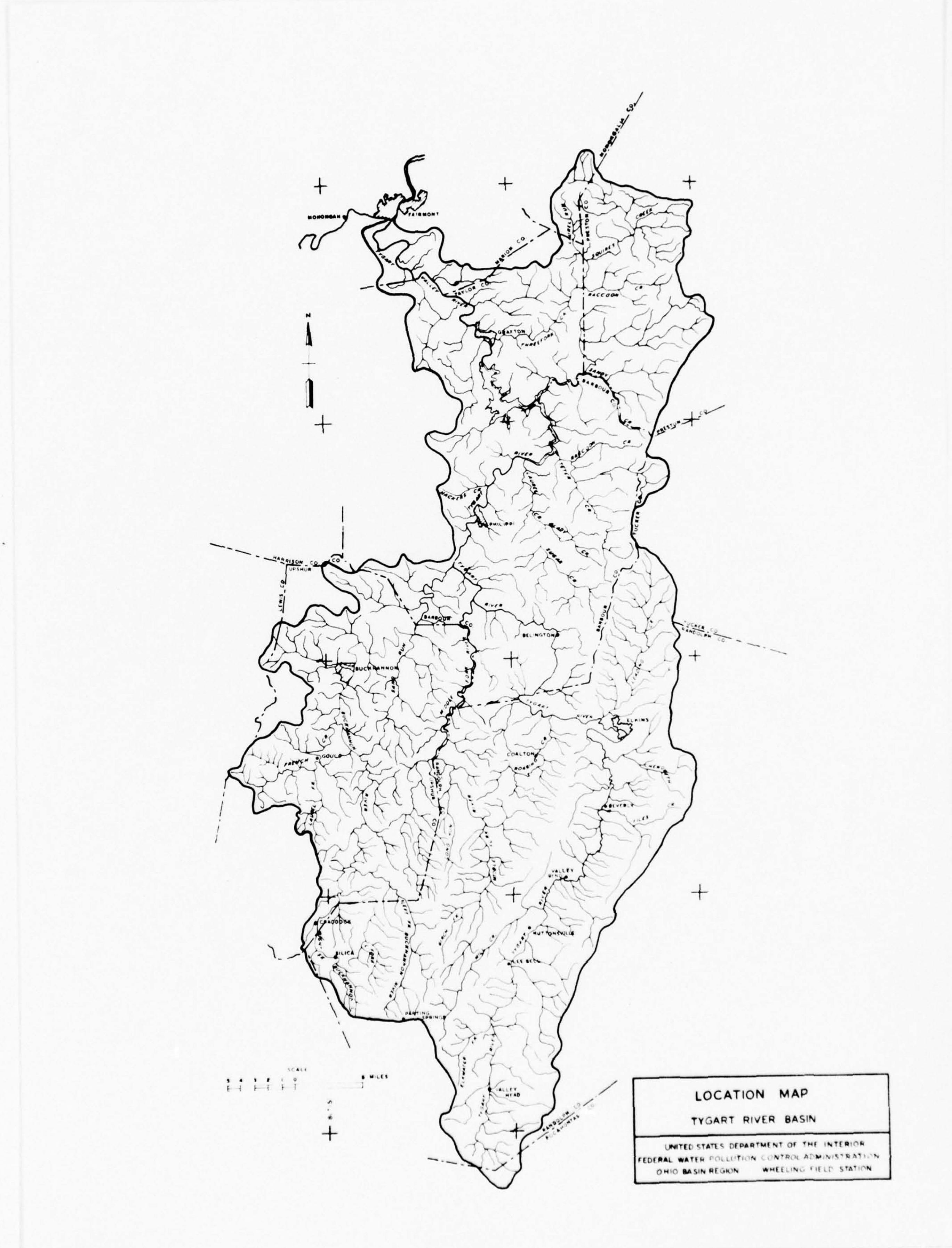
MINE DRAINAGE EFFECTS ON QUALITY OF WATER

In the following areas in the basin, the present and the potential uses of surface water are impaired as a result of the' characteristics inherent in mine drainage:

(A) Tygart Valley River between Grafton and Fairmont, and at Belington where quality of water is affected by high acidity.

(B) Roaring Creek, where quality of water is affected by high acidity, iron, manganese, sulfate, and hardness.

(C) Buckhannon River at Buckhannon, where quality of water is affected by iron, manganese, sulfate, and hardness.



LOCATION MAP
TYGART RIVER BASIN
UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION
WHEELING FIELD STATION
MONONGAH
FAIRMONT
MONONGALIA CO.
PRESTON CO.
MARION CO.
TAYLOR CO.
GRAFTON
RACCOON CR.
BARBOUR CO.
HARRISON CO.
UPSHUR CO.
LEWIS CO.
PHILIPPI
BELINGTON
BUCKHANNON
TUCKER CO.
RANDOLPH CO.
ELKINS
COALTON
BEVERLY
FRENCH CR.
GOULD
CRADDOCK
SILICA
VALLEY BEND
HUTTONSVILLE
MINGO
PICKENS
VALLEY HEAD
POCAHONTAS CO.
SCALE
MILES

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

WEST FORK RIVER BASIN

WEST VIRGINIA

prepared for

U. S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS-APPALACHIA STUDY
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The streamflow needs given in the tables do not necessarily agree with needs given in other reports prepared by Federal Water Pollution Control Administration because of the use of different economic projection data.

DESCRIPTION OF EXISTING CONDITIONS AND UTILIZATION

(1) Water Supply

The following municipalities have their public water supply sources in the West Fork River basin:

COUNTY	MUNICIPALITY	POPULATION SERVED	SOURCE OF SUPPLY	SAFE YIELD* (MGD)	PRESENT USE (MGD)
Harrison	Clarksburg, W.Va.	39,938	West Fork River	1.6 S-300	4.9
Harrison	Bridgeport, W.Va.	5,500	Hinkle and Digman Lakes	0.0	0.5
Harrison	Salem, W. Va.	3,000	Watershed Project Reservoirs (Dog Run Res.)	0.1	0.25
Lewis	Weston, W.Va.	7,000	West Fork River	0.05	0.6

*For surface-water sources, this is taken to be the 1-day-30-year low flow, (S-Present impoundment capacity in million gallons.) For ground water sources, this is the total reliable yield.

(2) Water Quality Control

Municipalities that have sewerage facilities discharging into the drainage of the West Fork River basin are as follows:

COUNTY	MUNICIPALITY	POPULATION SERVED	RECEIVING STREAM	PRESENT TYPE TREATMENT*	LOW FLOW** (cfs)
Harrison	Bridgeport, W.Va.	1,580	Simpson Creek		0.3
Harrison	Clarksburg, W.Va.	32,000	West Fork River		5.6
Harrison	Salem, W.Va.	3,000	Tenmile Creek	S, C	0.2
Lewis	Weston, W.Va.	8,300	West Fork River	S, C	0.14
Marion	Monongah, W.Va.	2,400	West Fork River	P, C	11.2

* S - Secondary, P - Primary, C - Chlorination
**7 Consecutive day onee in 10-year frequency

ANTICIPATED FUTURE CONDITIONS

(1) Water Supply

The following tables show projected streamflow requirements by the year 2020 for municipal water supply where a low-flow problem will exist. These flow needs are based on the U. S. Army Corps of Engineers' developmental benchmark projections.

Municipal Water Needs

COUNTY	AREA	PROJECTED TOTAL WATER SUPPLY REQUIREMENT 2020 (MGD)	
Harrison	Bridgeport, West Virginia	1.3	
Harrison	Salem, West Virginia	0.6	
Lewis	Weston, West Virginia	1.0	
Harrison	Clarksburg, West Virginia	S-300	11.2

(2) Water Quality Control

The following table shows projected streamflow requirements by the year 2020, for water quality control to assimilate municipal and industrial wastes where a low-flow problem will exist. The flow needs are based on the benchmark projections:

Municipal and Industrial Wastes (Water Quality Control Needs)

COUNTY	MUNICIPALITY	RECEIVING STREAM	TOTAL STREAMFLOW REQUIRED -2020 (cfs)
Harrison	Bridgeport, W.Va.	Simpson Creek	2
Harrison	Clarksburg, W.Va.	West Fork River	100
Harrison	Salem, W.Va.	Tenmile Creek	5
Lewis	Weston, W.Va.	West Fork River	14

WATER QUALITY OF POTENTIAL RESERVOIR SITES

The following is a preliminary evaluation of the water quality characteristics of potential reservoir sites in the West Fork River basin:

1. Ten Mile Creek

A water quality reservoir site with poor potential. It is not recommended for water quality control storage. The stream (2 samples) had pH values of 3.3 and 4.0, conductance of 3300 umhos/cm, acidity of 116 and 318 mg/l, alkalinity of 0 mg/l, hardness of 444 and 864 mg/l, iron of 43 and 65 mg/l,

sulfate of 1,100 and 1,500 mg/l, aluminum of 50 and 55 mg/l, chloride of 11 and 18 mg/l, 5 day BOD of 0 and 0.2 fecal coliform < 10/100 ml and fecal streptococci < 10/100 ml. The stream was heavily silted and the substrate was covered with reddish deposits typical of acid mine drainage. No living organisms were observed.

2. Elk Creek

A water quality reservoir site with poor potential. It is not recommended for water quality control storage. The stream (4 samples) had a pH range of 3.0-3.2, conductance of 1,600-2,800 umhos/cm, dissolved oxygen of 5.4-9.0 mg/l, acidity of 152-260 mg/l, alkalinity of 0 mg/l, hardness of 780-1,120 mg/l manganese of 6.6-8.1, sulfates of 425-1,500 mg/l, chloride of 10-17 mg/l, 5 day BOD of 0.6-3.0 mg/l, iron of 5.0-15.4 mg/l, total coliform of 4-70/100 ml, and fecal streptococci of 2-100/100 ml, and fecal coliform of 2-10/100 ml. The substrate consisted predominately of silt. No organisms were found.

3. Hackers Creek

A water quality reservoir site with poor to good potential. The stream (3 samples) had a pH range of 6.7-7.4, conductance of 520-1,040 umhos/cm, dissolved oxygen of 5.5-11.1 mg/l, acidity of 0-46 mg/l, alkalinity of 30-73 mg/l, hardness of 216/376 mg/l, manganese of 0.0-1.0 mg/l, sulfates of 205-1,000 mg/l, chlorides of 6-14 mg/l, 5 day BOD of 1.0-1.8 mg/l, iron of 0.3-0.6 mg/l, total coliform of 4,400-7,000/100 ml,

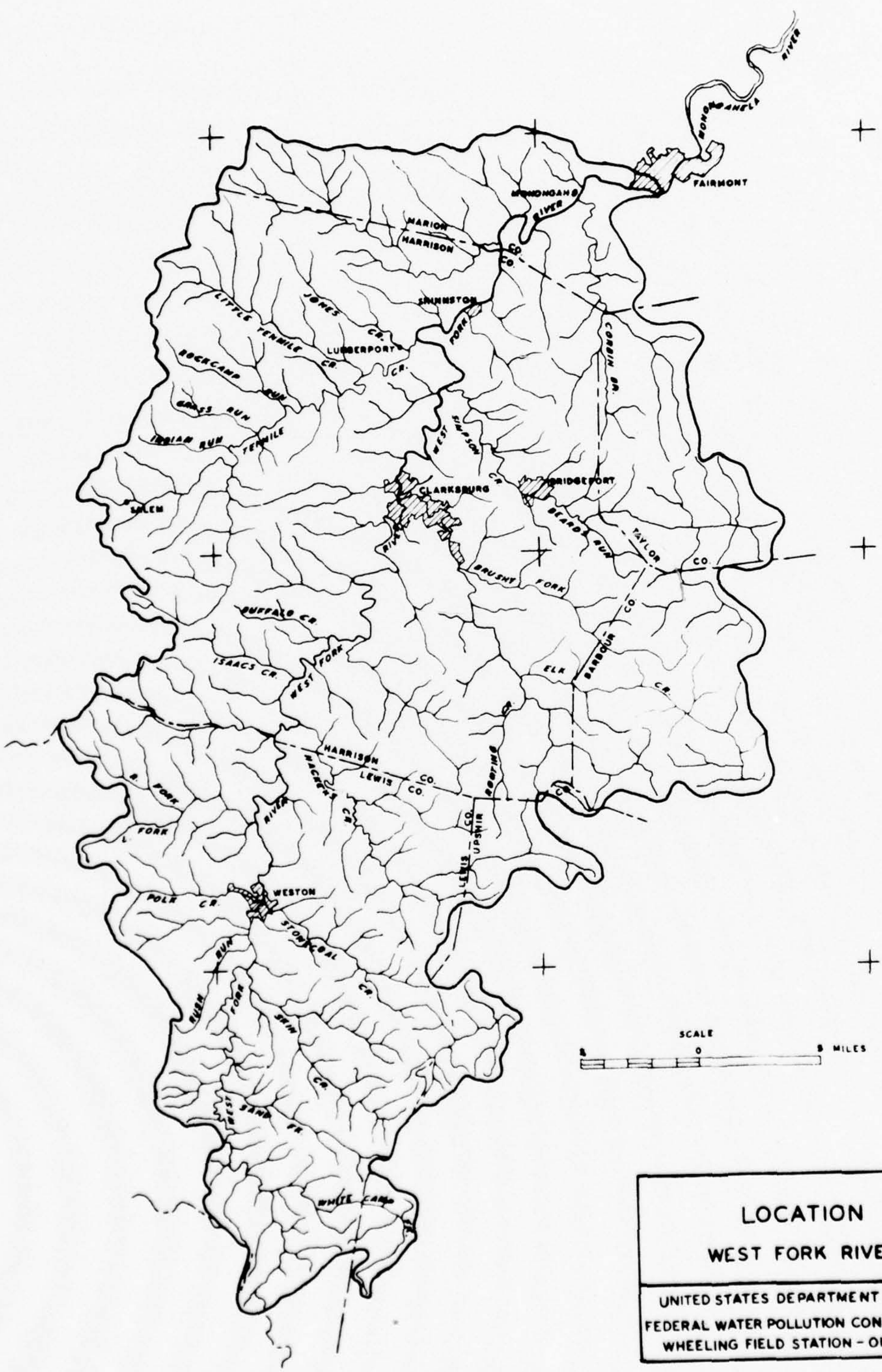
fecal coliform of 110-600/100 ml, and fecal streptococci of 630-1,100/100 ml. The substrate consisted entirely of silt. The bottom fauna reflected the poor substrate habitat.

MINE DRAINAGE EFFECTS ON QUALITY OF WATER

In the following areas of the basin, the present and the potential uses of surface water are impaired as a result of the characteristics inherent in mine drainage such as high acidity, iron, manganese, sulfate, and hardness.

(A) West Fork River from Clarksburg to Fairmont, West Virginia.

(B) Jones Creek near Lumberport, Harrison County, West Virginia.



LOCATION MAP

WEST FORK RIVER BASIN

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
WHEELING FIELD STATION - OHIO BASIN REGION

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

YOUGHIOGHENY RIVER BASIN

PENNSYLVANIA, MARYLAND, AND WEST VIRGINIA

prepared for

U. S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS-APPALACHIA STUDY
U. S. ARMY ENGINEER DISTRICT
PITTSBURGH, PENNSYLVANIA

by

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION
WHEELING FIELD STATION

December 1967

APPALACHIAN REGION WATER RESOURCES
DEVELOPMENT PROGRAM

Youghiogheny River Basin

Pennsylvania, Maryland, and West Virginia

Framework Report for Water Supply
and
Water Quality Control

Request and Authority

In a letter dated March 3, 1967, the Pittsburgh District, U. S. Army Corps of Engineers, requested the Federal Water Pollution Control Administration, Wheeling Field Station, Ohio River Basin Project, to prepare a generalized, framework type report on the Youghiogheny River basin. (See drainage area map.) The Youghiogheny is a potential water development area in the Appalachian Region.

The authority to conduct this study is contained in the Appalachian Regional Development Act of 1965, PL 89-4, Section 206-C.

Purpose and Scope

This study determines the general projected need of streamflow for water supply and water quality control in the Youghiogheny River basin. These needs are based on population benchmarks that reflect the developmental effect of the Appalachian Program on the area. The report is generalized and is not intended to be utilized for authorization of water development projects at specific locations. It is intended that specific streamflow requirements given in this report be used to screen potential reservoir projects for more detailed evaluation in the future.

Rationale Utilized in this Study

This report evaluates the general municipal and industrial water supply and water quality control needs in terms of total streamflow requirements by the year 2020 in areas which will need additional storage to solve low flow problems. In analyzing potential problem areas,it was assumed that existing communities would grow at the same rate as indicated by their respective county population benchmark projections. Industrial water use and waste loads were based upon benchmark employment projections as disaggregated to the county level by the U. S. Army Corps of Engineers, Pittsburgh District. Such projections were further distributed to stream reaches according to the location of present industrial establishments and to the apparent land availability adjacent to the major streams.

The streamflow needs given in tables do not necessarily agree with needs given in other reports prepared by Federal Water Pollution Control Administration because of the use of different economic projection data.

DESCRIPTION OF EXISTING CONDITIONS AND UTILIZATION

(1) Water Supply

The following municipalities have their public water supply sources in the Youghiogheny River basin:

STATE	COUNTY	MUNICIPALITY	POPULATION SERVED	SOURCE OF SUPPLY	SAFE YIELD* (MGD)*	PRESENT USE (MGD)
Pa.	Allegheny	McKeesport	75,000	Youghiogheny River	N	63.0
Pa.	Allegheny	Elizabeth	37,600	Monongahela River	N	5.0
Pa.	Somerset	Meyersdale	3,000	Crystal Lake	0.1	0.2
Pa.	Fayette	Connellsville	25,000	Youghiogheny River and Laurel Run	17.4	2.5
W.Va.	Preston	Terra Alta	1,700	5 wells 2 in use	0.3	0.12
Md.	Garrett	Oakland	5,000	Youghiogheny River	4.0	0.2
Pa.	Somerset	Somerset	8,000	Laurel Hill Creek & Emergency Wells		1.2
Pa.	Westmoreland	Westmoreland County Municipal Authority	200,000	Beaver Run Indian Cr. Immel Reservoir	39.9	23.5

*For surface-water sources, this is taken to be the 1-day-30 year low flow; (N, Intake in navigation pool, supply essentially unlimited).

For ground-water sources, this is the total reliable yield.

(2) Water Quality Control

The following municipalities have sewerage facilities discharging into the Youghiogheny River basin:

STATE	COUNTY	MUNICIPALITY	POPULATION SERVED	RECEIVING STREAM	PRESENT TYPE TREATMENT*	LOW FLOW** (cfs)
Pa.	Westmoreland	Greensburg	24,000	Jack's Run	S-C	0.1
Pa.	Westmoreland	Mt.Pleasant	6,107	Shupes Run and Sherricks Run	S-C	0.0
Pa.	Westmoreland	Scottdale	6,244	Jacobs Creek	S -C	1.0
Pa.	Westmoreland	West Newton	3,982	Youghiogheny River	None	88
Pa.	Westmoreland	Youngwood	3,000	Jacks Run	S-C	0.3
Pa.	Westmoreland	Hempfield (Carbon)		Jacks Run	S-C	0.04
Pa.	Westmoreland	Hempfield (Eastwood)		Township Line Run	I-C	0.24
Pa.	Westmoreland	Hempfield (Rolling Hills)		Sewickley Creek	S-C	0.42
Pa.	Westmoreland	Hempfield (New Stanton)		Sewickley Creek	P-C	0.42
Pa.	Allegheny	McKeesport	80,000	Monongahela River	I-C	637.
Pa.	Allegheny	Elizabeth Twp.	14,160	Monongahela River	S-C	472.
Pa.	Somerset	Meyersdale	2,900	Casselman River	S Waste Stabilization	6.3
Pa.	Somerset	Somerset	6,000	Coxes Cr.	S-C	0.5
Md.	Garrett	Oakland	5,000	Little Youghiogheny	None	5.0

*S - Secondary, P - Primary, I - Intermediate, C - Chlorination.

**7 consecutive day once in 10-year frequency.

ANTICIPATED FUTURE CONDITIONS

(1) Water Supply

The following table shows projected total streamflow requirements by the year 2020 for municipal water supply where a low-flow problem will exist. These flow needs are based on the U. S. Army Corps of Engineers' developmental benchmark projections:

Municipal Water Needs

STATE	COUNTY	AREA	PROJECTED TOTAL WATER SUPPLY REQUIREMENT 2020 (MGD)
Pa.	Somerset	Meyersdale	0.7
Pa.	Westmoreland	Westmoreland County Municipal Authority	48 treated, 17 raw 1/
Pa.	Somerset	Somerset	3.1

1/ Projected to the year 2010 as determined by the State of Pennsylvania.

The Westmoreland County Municipal Authority is now planning to go to the Youghiogheny River as a source of water supply.

(2) Water Quality Control

The following table shows projected total streamflow requirements by the year 2020 for municipal and industrial water quality control where a low-flow problem will exist. These flow needs are based on the benchmark projections:

Municipal and Industrial Wastes (Water Quality Control Needs)

STATE	COUNTY	AREA	RECEIVING STREAM	TOTAL STREAMFLOW REQUIRED - 2020 (cfs)
Pa.	Westmoreland	Greensburg	Sewickley Creek	68
Pa.	Westmoreland	Mt. Pleasant	Shupes Run Sherricks Run	11
Pa.	Westmoreland	Scottdate	Jacobs Creek	14
Pa.	Westmoreland	Youngwood	Jacks Run	5
Pa.	Westmoreland	Hempfield (Carbon)	Jacks Run	4
Pa.	Westmoreland	Hempfield (Eastwood)	Township Line Run	6
Pa.	Westmoreland	Hempfield (New Stanton)	Sewickley Creek	1
Pa.	Fayette	Connellsville	Youghiogheny River	260
Pa.	Somerset	Somerset	Coxes Creek	14

WATER QUALITY OF POTENTIAL RESERVOIR SITES

The following is a preliminary evaluation of the water quality characteristics of potential reservoir sites in the Youghiogheny River basin:

1. Jacobs Creek

   A water quality reservoir site with good potential. The stream (3 samples) had a pH range of 6.6-8.7, conductance of 380-500 umhos,dissolved oxygen of 7.9-10.7 mg/l, acidity of 6-28 mg/l, alkalinity of 27-29 mg/l, hardness of 155-380 mg/l, manganese of 0.0-0.2 mg/l, sulfate of 50-140 mg/l, chloride of 21-28 mg/l, 5-day BOD of 0.1-2.9 mg/l, iron of 0.1-0.6 mg/l, total coliform of 4,400-31,000/100 ml, fecal coliform of 54-64/100 ml, fecal streptococci of 68-610/100 ml. Bottom fauna at this station was scarce.

2. Laurel Hill Creek

   A water quality reservoir site with good potential. The stream (6 samples) had a pH range of 6.4-7.3, conductance of 41-90, umhos/cm, dissolved oxygen of 8.7-12.0 mg/l, acidity of 5-26 mg/l, alkalinity of 3-21 mg/l, hardness of 32-56 mg/l, manganese of 0.0-0.3 mg/l, sulfate of 4-15 mg/l, chloride of 2.6 mg/l, 5-day BOD of 0.2-2.1 mg/l, iron of 0.0-1.0 mg/l, total coliform of 10-14,000/100 ml, fecal coliform of 2-420 mg/l, and fecal streptococci of 2-1,600 mg/l. This station had a low density of bottom organisms, but showed no evidence of water pollution.

3. **Upper Casselman River (above Salisbury, Pa.).**

A water quality reservoir site with good potential.

The stream (3 samples) had a pH range of 6.0-7.8, a conductance of 50-290 umhos/cm, dissolved oxygen of 7.5-12.6 mg/l, acidity of 9-35 mg/l, alkalinity of 4-28 mg/l, hardness of 50-154 mg/l, manganese of 0.0-1.0 mg/l, sulfate of 20-94 mg/l, chloride of 6-17 mg/l, 5-day BOD of 0.4-3.1 mg/l, iron of 0.1-2.1 mg/l, total coliform of 6,000-98,000/100 ml, fecal coliform of 110-5,300/100 ml, and fecal streptococci of 170-4,700/100 ml. The bottom fauna at this station is characterized by an abundance of tolerant forms associated with domestic pollution recovery zones.

4. **Upper Youghiogheny River (above Crellin, Md.).**

A water quality reservoir site with good potential.

The stream (3 samples) has a pH range of 6.3-7.8, a conductance of 50-125 umhos/cm, dissolved oxygen of 6.2-11.8 mg/l, acidity of 0-27 mg/l, alkalinity of 5-46 mg/l, hardness of 30-74 mg/l, manganese of 0.0-0.5 mg/l, sulfate of 0-12 mg/l, chlorides of 0-6 mg/l, 5-day BOD of 0.2-3.0 mg/l, iron of 0.4-3.5 mg/l, total coliform of 240- 24,000/100 ml, fecal coliform of 2-650/100 ml, and fecal streptococci of 2-730/100 ml. Aquatic organisms at this station were few. They consisted predominately of intolerant forms.

MINE DRAINAGE EFFECTS ON QUALITY OF WATER

The following areas in the Youghiogheny River basin are polluted and severely degraded by mine drainage. The damaging characteristics of mine drainage are high acidity, low pH, and high concentrations of iron, manganese, sulfate hardness, and dissolved solids.

A. The Youghiogheny River just above McKeesport, and below Connellsville and the Casselman River is affected by high acidity.

B. Snowy Creek in the extreme headwaters of the basin has been affected by high acidity, iron, manganese, sulfate, and hardness. Current mine drainage remedial work may improve the water quality in this stream.


LOCATION MAP
YOUGHIOGHENY RIVER BASIN
UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION
WHEELING FIELD STATION
HEMPFIELD TWP
SCOTTDALE
CONNELLSVILLE
CONFLUENCE
ROCKWOOD
BERLIN
SOMERSET
PENNSYLVANIA
MARYLAND
WESTMORELAND CO
FAYETTE CO
PRESTON CO
GARRETT CO
SOMERSET CO
WEST VIRGINIA
TERRA ALTA
OAKLAND
SCALE
MILES

APPALACHIAN REGION WATER RESOURCES

DEVELOPMENT PROGRAM

FRAMEWORK REPORT

FOR

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

CONEWANGO CREEK BASIN, NEW YORK
CASSADAGA CREEK BASIN, NEW YORK
BROKENSTRAW CREEK BASIN, PENNSYLVANIA AND NEW YORK
RACCOON CREEK BASIN, PENNSYLVANIA
BIG SANDY CREEK BASIN, WEST VIRGINIA AND PENNSYLVANIA
DUNKARD CREEK BASIN, WEST VIRGINIA AND PENNSYLVANIA

prepared for

U. S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS-APPALACHIA STUDY
U. S. ARMY ENGINEER DISTRICT
PITTSBURGH, PENNSYLVANIA

by

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION
WHEELING FIELD STATION

December 1967

Request and Authority

In a letter dated October 9, 1967, the Pittsburgh District, U. S. Army Corps of Engineers, requested the Federal Water Pollution Control Administration, Wheeling Field Station, Ohio River Basin Project to prepare a generalized framework type report on the following drainage basins which are potential water development areas in the Appalachian Region:

Conewango Creek basin, New York

Cassadaga Creek basin, New York

Brokenstraw Creek basin, Pennsylvania and New York

Raccoon Creek basin, Pennsylvania

Big Sandy Creek basin, West Virginia and Pennsylvania

Dunkard Creek basin, West Virginia and Pennsylvania

The authority to conduct this study is contained in the Appalachian Redevelopment Act of 1965 PL 89-4, Section 206-C.

Purpose and Scope

This study determines the general projected need of streamflow for water supply and water quality control in the above mentioned drainage basins. These needs are based on population benchmarks that reflect the developmental effect of the Appalachian Program on the area. The report is generalized and is not intended to be utilized for authorization of water development projects at specific locations. It is intended that specific streamflow requirements given in this report be used to screen potential reservoir projects for more detailed evaluation in the future.

Rationale Utilized in this Study

This report evaluates the general municipal and industrial water supply and water quality control needs in terms of total streamflow requirements by the year 2020 in areas which will need additional storage to solve low flow problems. In analyzing potential problem areas, it was assumed that existing communities would grow at the same rate as indicated by their respective county population benchmark projections. Industrial water use and waste loads were based upon benchmark employment projections as disaggregated to the county level by the U. S. Army Corps of Engineers, Pittsburgh District. Such projections were further distributed to stream reaches according to location of present industrial firms and to the apparent land availability adjacent to the major streams.

The streamflow needs given in the tables do not necessarily agree with needs given in other reports prepared by FWPCA because of the use of different economic projection data.

CONEWANGO CREEK AND CASSADAGA CREEK BASINS, NEW YORK

Calculations based on the developmental benchmark projections indicate that there is a need for storage to provide low-flow augmentation on Cassadaga Creek below Jamestown, New York for proper waste assimilation after secondary treatment of municipal and industrial organic wastes. The total flow requirement projected for the year 2020 is 200 cubic feet per second.

Stream samples (2) at station 801 on Conewango Creek, several miles southeast of Jamestown, New York, had pH values of 7.1 and 7.3, conductance of 145 and 230 umhos/cm, dissolved oxygen of 9.5 and 11.5 mg/l, acidity of 12 and 28 mg/l, alkalinity of 26 and 59 mg/l, hardness of 43 and 83 mg/l, sulfates of 15 and 25 mg/l, total iron of 0.4 and 1.2 mg/l, manganese of 0.1 and 0.2 mg/l, turbidity of 8 and 18 J.C.U., arsenic 0 mg/l, chloride of 8 and 12 mg/l, BOD_5 of 1.4 mg/l, fecal coliform of 80 and 1,100/100 ml, fecal streptococci of 30 and 550/100 ml, total coliform of 360 and 9,000/100 ml, total solids of 148 mg/l, dissolved solids of 142 mg/l, suspended solids of 6 mg/l, phenols 0 mg/l, cyanide 0 mg/l, and hex. chromium 0 mg/l.

Conewango Creek is characterized by a reduced bottom fauna. The substrate was poor and there was considerable siltation.

Although no laboratory analyses are available for Cassadaga Creek, an aquatic biologic reconniassance survey showed that the bottom fauna was dominated by a variety of clean water forms. The stream was clear, however a tar-like material was observed in the substrate.

BROKENSTRAW CREEK BASIN, PENNSYLVANIA AND NEW YORK

Brokenstraw Creek is reported to be an excellent stream for trout fishing. The stream is usually stocked each year. The ponding of any section of this stream would destroy the trout fishing in that section.

Stream samples (2) taken at Station 600 in Pennsylvania had pH values of 7.1 and 7.7, conductance of 70 and 130 umhos/cm, dissolved oxygen of 11.5 mg/l, acidity of 0 and 9 mg/l, alkalinity of 22 and 25 mg/l, hardness of 40 mg/l, sulfate of 15 and 20 mg/l, total iron of 0.6 and 1.0 mg/l, manganese of 0 and 0.2 mg/l, turbidity of 4 and 40 J.C.U., chloride of 6 and 8 mg/l, BOD_5 of 0.8 and 2.7 mg/l, total coliform of 380 and 2500/100 ml, fecal coliform of 60 and 760/100 ml, and fecal streptococci of 80 and 9,500/100 ml.

The bottom fauna of Brokenstraw Creek was composed of a wide variety of benthic forms. The stream was clear and appeared to be in good condition.

The community of Corry, Pennsylvania is presently using a number of wells as their water supply source. Future projections indicate additional water will be needed. This could be accomplished either through expansion of the present well field or from storage of surface water.

There is need for surface storage to provide low flow augmentation for water quality control on Hare Creek at Corry, Pennsylvania. It is estimated that a total flow of 15 cfs will be needed by the year 2020 for proper waste assimilation.

RACCOON CREEK BASIN, PENNSYLVANIA

Raccoon Creek above Burgettstown, Washington County, Pennsylvania, is not affected by mine drainage. However, below Burgettstown, the Raccoon is severely degraded because of several tributaries that are severely degraded. The water in Raccoon downstream from Burgettstown is not satisfactory for water supply, water quality control, or recreation. Tributaries to the Raccoon in Beaver County, however, are not affected by mine drainage.

Stream samples (6) at station 588, several miles downstream from the dam site had a pH range of 3.3 to 5.1, conductance of 800-2,000 umhos/cm, dissolved oxygen of 6.1 - 8.7 mg/l, acidity of 131-362 mg/l, alkalinity of 0 mg/l, hardness of 345-816 mg/l, sulfates of 305-800 mg/l, total iron of 0.1 - 7.2 mg/l, manganese of 1.1 - 14.7 mg/l, aluminum of 0-69.4 mg/l, and chloride of 31 mg/l.

Along Raccoon Creek the rocks were stained red and were apparently somewhat cemented together. There was also a grayish deposit on the rocks. The variety of bottom fauna was low, and was dominated by pollution-tolerant forms.

There are no known major water supply or water quality control problems in the immediate vicinity of the proposed reservoir site.

DUNKARD CREEK BASIN, WEST VIRGINIA AND PENNSYLVANIA

Laboratory analyses of stream samples obtained from stations along Dunkard Creek are given below. These analyses show that the water downstream from Bobtown, Pennsylvania (Station 0444) is severely degraded by mine drainage, whereas those analyses from stations upstream from Bobtown, Pennsylvania (0445, 0333, 0332, and 0811) show water of better quality.

Stream samples (9), at station 0444 about 2 miles above Mount Morris, Pennsylvania, had a pH range of 3.1 to 7.5, conductance of 240-3500 mg/l, dissolved oxygen of 6.9 - 11.5 mg/l, acidity 0.0 - 535 mg/l, alkalinity of 0.0 - 82.0 mg/l, hardness of 94-820 mg/l, sulfate of 79 - 1500 mg/l, total iron of 2.2 - 22.2 mg/l, manganese of 0.2 - 6.0 mg/l, chloride of 44 - 101 mg/l, BOD_5 of 0 - 6.5 mg/l, total coliform of 116-14,200/100 ml, fecal coliform of 2 - 490/100 ml, and fecal streptococci 2-170/100 ml.

Stream samples (6) at station 0445 upstream from Shannopin, Pennsylvania, had a pH range of 6.4 to 8.1, conductance of 200-2,800 umhos/cm, dissolved oxygen of 8.4 - 9.7 mg/l, acidity of 0.0 - 37.0 mg/l, alkalinity of 26-130 mg/l, hardness of 78-390 mg/l, sulfates of 51-900 mg/l, total iron of 0.2 - 2.7 mg/l, manganese of 0.0 - 0.1 mg/l, turbidity of 25 J.C.U., chloride of 34-147 mg/l, BOD_5 of 2-3 mg/l, fecal coliform of 30 - 470/100 ml, fecal streptococci of 170 - 630/100 ml, and total coliform of 2,500 to 82,000/100 ml.

A stream sample taken February 2, 1967 at Station 0333 on Dunkard Creek on the West Virginia-Pennsylvania line about a mile upstream from Mount Morris, Pennsylvania had a pH of 6.9, conductance of 420 umhos/cm, dissolved oxygen of 10.5 mg/l, acidity of 0 mg/l, alkalinity of 35 mg/l, hardness of 95 mg/l, sulfate of 80 mg/l, total iron of 0.7 mg/l, manganese of 0.2 mg/l, chloride of 41 mg/l, BOD_5 of 0.5 mg/l, total coliform of 140/100 ml, fecal coliform of 30/100 ml, fecal streptococci of 130/100 ml, total solids of 266 mg/l, dissolved solids of 252 mg/l, and suspended solids of 14 mg/l.

A stream sample taken February 2, 1967 at Station 0332 on Dunkard Creek on the West Virginia-Pennsylvania line, about a mile down-stream from Blacksville, West Virginia, had a pH of 7.1, conductance of 190 umhos/cm, dissolved oxygen of 11.9 mg/l, acidity of 0 mg/l, alkalinity of 26 mg/l, hardness of 59 mg/l, sulfate of 35 mg/l, total iron of 0.4 mg/l, manganese of 0.2 mg/l, chloride of 11 mg/l, BOD_5 of 0.5 mg/l, total coliform of 4300/100 ml, fecal coliform of 1200/100 ml, fecal streptococci of 640/100 ml, total solids of 106 mg/l, dissolved solids of 96 mg/l, and suspended solids of 10 mg/l.

A stream sample taken February 2, 1967 at Station 0811 on the headwaters of Dunkard Creek at Shamrock, Pennsylvania, had a pH of 7.5, conductance of 145 umhos, acidity of 0 mg/l, alkalinity of 21 mg/l, hardness of 56 mg/l, sulfate of 30 mg/l, total iron of 1.0 mg/l, manganese of 0.2 mg/l, chloride of 8 mg/l, BOD_5 of 0.6 mg/l, total coliform of 1000/100 ml, fecal coliform of 310/100 ml, fecal streptococci of 370/100 ml, total solids of 96 mg/l, dissolved solids of 82 mg/l, and suspended solids of 14 mg/l.

The upper portion of Dunkard Creek supports a variety of clean water benthic forms. The lower portion of the stream near Bobtown, Pennsylvania, has a severely reduced bottom fauna and the bottom is covered with a heavy orange precipitate.

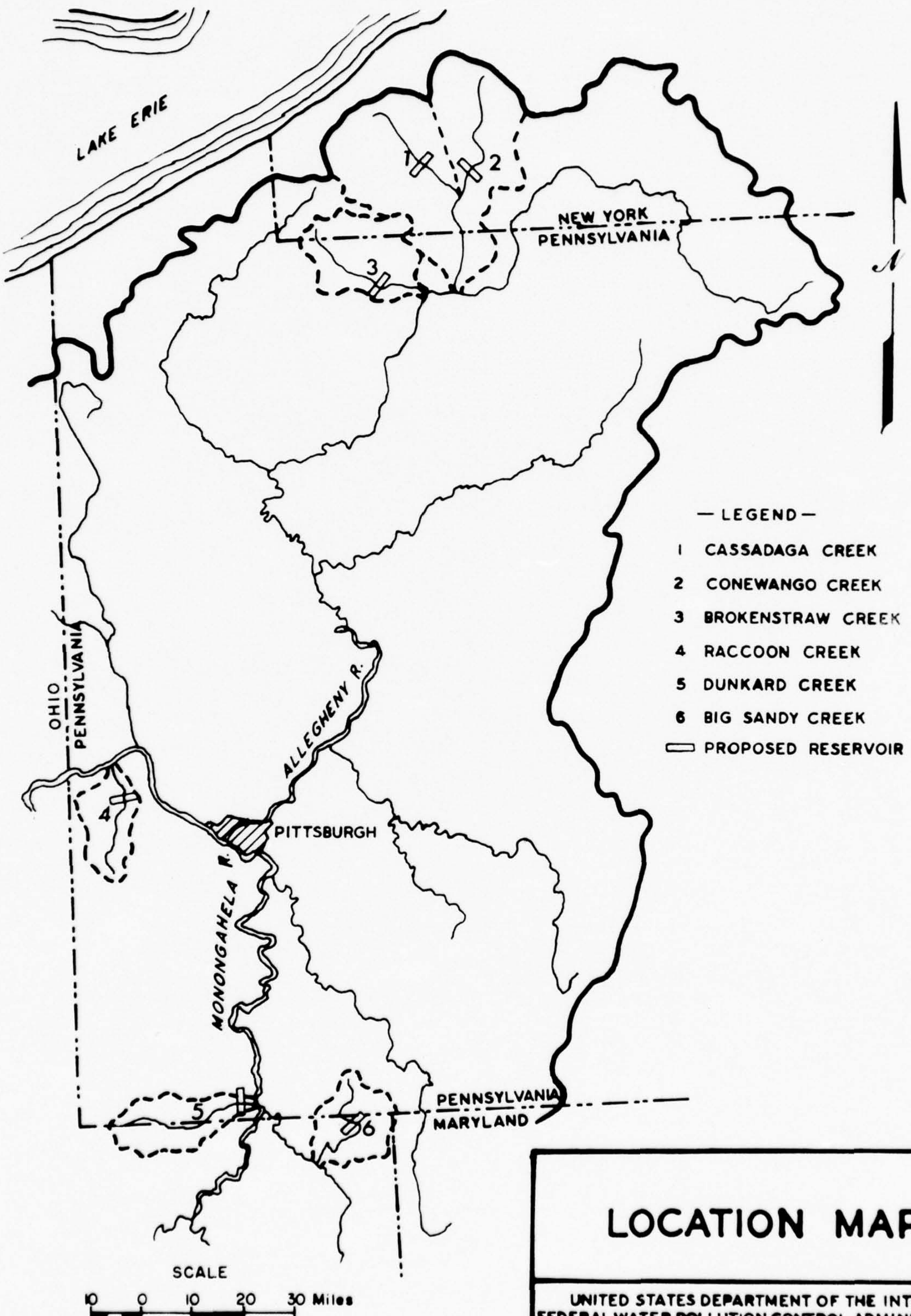
There are no known major water supply or water quality control problems in the immediate vicinity of the proposed reservoir site.

BIG SANDY CREEK BASIN, WEST VIRGINIA AND PENNSYLVANIA

Big Sandy Creek at Bruceton Mills, Preston County, West Virginia, supports typical clean water benthic forms. This section of the stream is annually stocked with trout by the West Virginia Department of Natural Resources.

A stream sample taken on February 1, 1967 at station 818 in Big Sandy Creek in Pennsylvania had a pH of 7.3, conductance of 65 umhos/cm, acidity of 17 mg/l, alkalinity of 12 mg/l, hardness of 21 mg/l, sulfate of 15 mg/l, total iron of 0.3 mg/l, manganese of 0.2 mg/l, turbidity of 9 J.C.U., chloride of 8 mg/l, BOD_5 of 0.1 mg/l, total coliform of 200/100 ml, fecal coliform of 10/100 ml, fecal streptococci of 20/100 ml, total solids of 43 mg/l, dissolved solids of 39 mg/l, and suspended solids of 4 mg/l.

There are no known major water supply or water quality control problems along Big Sandy Creek. The water is of acceptable quality for recreational purposes.



LOCATION MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
WHEELING FIELD STATION - OHIO BASIN REGION

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

Whiteoak Creek Basin

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Ohio Basin Region
Cincinnati, Ohio

C
O
P
Y

Ohio River Basin Project
550 Main Street, Room 7405, Cincinnati, Ohio 45202

October 13, 1967

Your reference:
ORHED-PK

Colonel William D. Falck
District Engineer
U.S. Army Engineer District, Huntington
P.O. Box 2127
Huntington, West Virginia 25721

Dear Colonel Falck:

The report on "Water Resources Study - Whiteoak Creek Basin - Ohio," dated August 1962, has been re-evaluated based upon the Developmental Benchmarks, as requested in your letter of April 28, 1967.

Projected municipal and industrial water supply requirements are as follows:

	1980	2000	2020
Whiteoak Creek Basin	1.65 MGD	4.70 MGD	6.20 MGD
Georgetown	0.40	1.20	1.80
Mount Orab	0.20	0.50	0.85
Sardinia	0.10	0.30	0.45
Mowrystown	0.06	0.08	0.10

At the present time there are only three municipal water systems in the basin. They are Georgetown, Mount Orab and Sardinia, using Whiteoak Creek, Sterling Run and East Fork respectively as sources of supply. Mowrystown relies on individual wells and cisterns for their supply. Mowrystown is in an area in which wells yielding 5 to 25 gallons per minute can be developed; however it appears that in the near future they will require a municipal water supply and have therefore been included in the projections.

Due to the anticipated location of future manufacturing industries and lack of heavy water using industries in the past, no projections were derived for heavy water using industries for the future. However, should industries locate in the basin as indicated in the U.S. Army Corps of Engineers "Appendix A, Industrial Development Plan", water supply requirements could increase by another 1.7 MGD in the year 2020.

Georgetown is the only community located downstream from the proposed reservoir and is therefore the only community whose waste could be assimilated by water released from that reservoir.

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The assimilative capacity of a stream during the average seven-day-once-in-ten-year low flow is used as the criteria for determining the need for flow regulation for water quality control. It is assumed that secondary treatment, 85% removal of biochemical oxygen demand (BOD), will be provided by the community of Georgetown. The residual waste waters are assumed to have an ultimate BOD of 45 milligrams per liter (mg/l), and a volume estimated to be 90% of the projected municipal and industrial water demand. The periods of critical flow will generally occur in the summer or early fall months; therefore, the natural flow and water released from the reservoir during the critical period is assumed to have the following characteristics:

a. average temperature of $20^{\circ}C$
b. BOD of 3 mg/l
c. dissolved oxygen (DO) of 80% saturation, or 7.2 mg/l
d. deoxygenation constant "k_1" of 0.10
e. reoxygenation constant "k_2" of 0.20

Based on the volume of waste water and the above assumptions, the following is a tabulation of the minimum stream flows required which would prevent the DO in the stream from falling below 4 mg/l.

	Waste Water Flow MGD	Minimum Stream Flow Required cfs
1980	0.40	1.7
2000	1.10	4.7
2020	1.65	7.0

Without flow regulation the seven-day-once-in-ten-year low flow at Georgetown is about 0.1 cfs. Since this value is below the projected minimum flow requirements, it is evident that flow regulation or other measures must be initiated to protect the water quality in Whiteoak Creek below Georgetown.

In 1965, the community of Mount Orab placed into operation a new sewage treatment plant providing secondary treatment. This effluent is discharged into Sterling Run which feeds into Lake Grant. It is assumed that Sardinia, located on the East Fork of Whiteoak Creek about 22 miles above the proposed reservoir, will provide secondary treatment for their wastes.

The small quantities of waste water flow from Mount Orab and Sardinia in relation to the volume of water in the proposed reservoir should not, with proper operation of the reservoir, create any nuisance in the reservoir.

Sincerely yours,

Victor F. Jelen
Deputy Project Director

RICantor:JWF/mt

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APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

ST. PETERSBURG RESERVOIR

CLARION RIVER, PENNSYLVANIA

ALLEGHENY RIVER BASIN

prepared for

U. S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS-APPALACHIA STUDY
U. S. ARMY ENGINEER DISTRICT
PITTSBURGH, PENNSYLVANIA

by

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION
WHEELING FIELD STATION

December 1967

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Request and Authority

In a letter dated 3 March, 1967, the U. S. Army Corps of Engineers District Engineer, Pittsburgh District, requested the Federal Water Pollution Control Administration to study the proposed St. Petersburg Reservoir Project with respect to potential water development for water supply and water quality control.

This report was prepared under the authority of the Appalachian Regional Development Act of 1965, P. L. 89-4, Section 206C.

Purpose and Scope

The purpose of this investigation was to determine the need for and value of water supply and/or water quality control storage in the proposed St. Petersburg Reservoir, located on the Clarion River in Clarion County, Pennsylvania. Economic projections were based upon the developmental benchmarks supplied by the U. S. Army Corps of Engineers, Pittsburgh District.

In analyzing water supply and water quality control needs consideration was given to present and potential water users and waste sources along the Allegheny River from the Allegheny River Reservoir near Warren, Pennsylvania, to Pittsburgh, Pennsylvania; the Ohio River from Pittsburgh, Pennsylvania, to the Pennsylvania-West Virginia state line, and areas adjacent to the proposed St. Petersburg Reservoir. The study was focused on the lower reaches of the Allegheny River and the Ohio River in the vicinity of Pittsburgh, Pennsylvania and this area presently has an established large municipal and industrial complex.

Summary of Findings

The existing water resources, with Allegheny River Reservoir in operation, can adequately meet the projected municipal and industrial water supply requirements of the study area.

The present stream flow conditions of the Allegheny River can adequately provide proper assimilation of treated municipal and industrial wastes under present and projected economic conditions.

There is a need for storage to provide low flow augmentation for projected water quality control needs on the Ohio River near Pittsburgh, Pennsylvania. Computations indicate that about 110,000 acre feet of storage is required to meet these flow needs nine out of ten years as projected to the year 2020. The average annual benefit from providing such storage is $1,001,000.

The quality of water in the Clarion River is degraded by acid mine drainage and therefore storage for water quality control is not recommended in St. Petersburg Reservoir unless corrective measures are applied to the existing acid drainage sources.

Physical Data

The proposed St. Petersburg Reservoir dam site is located on the Clarion River near its mouth, about 2 miles east of the Allegheny River bridge at Foxburg, Pennsylvania. The proposed reservoir site has an approximate storage capacity of 800,000 acre feet at the full pool elevation of 1140 feet and would control a drainage area of 1231 square miles. A considerable portion of the proposed 800,000 acre feet is available as storage for water supply and/or low flow augmentation for water quality control.

The Clarion River joins the Allegheny River near Parker, Pennsylvania. The Allegheny is a free flowing river at that point, but soon becomes navigable in the vicinity of East Brady, Pennsylvania, which is located about 20 miles downstream from Parker. There are eight navigation structures on the Allegheny River between East Brady, Pennsylvania, and the point at which it joins the Monongahela River at Pittsburgh, Pennsylvania, a distance of 72 miles. Thus, the major portion of the Allegheny River below the proposed St. Petersburg Reservoir is a series of navigation pools.

There are several existing reservoirs located in the Allegheny and Monongahela basins, some of which have an effect on low flow conditions in the study area. Existing and authorized Corps of Engineers' reservoirs in the Allegheny basin are located on Figure 1. Table 1 presents a summary of physical data related to the reservoirs which have an effect on the surface water resources in the study area.

TABLE 1

RESERVOIR DATA

ALLEGHENY AND MONONGAHELA BASINS

Reservoir	Storage - Summer Season (1000 Ac. Ft.)			
	Flood	Quality	Conservation	Total
Allegheny River 1/	607	549	24	1180
Conemaugh River 1/	270	---	4	274
Crooked Creek 1/	89	---	5	94
East Branch, Clarion River 1/	19	64	1	84
Loyalhanna 1/	93	---	2	95
Tionesta 1/	125	---	8	133
Rowlesburg*2/	251	572	9	832
Tygart River 2/	178	100	10	288
Youghiogheny River 2/	100	149	5	254
Stonewall Jackson** 2/	27	46	2	75

*Authorized for construction on Cheat River
**Authorized for construction on West Fork River

1/ Allegheny River basin (See Figure 1.)

2/ Monongahela River basin (Not shown Figure 1.)

U. S. Geological Survey streamflow measuring stations are located at several points in the study area. A summary of low flow frequency data at key stations is given in Table 2. Allegheny River flow data is presented under natural conditions and as augmented by East Branch and Allegheny Reservoirs. Ohio River flow data is presented under natural flow conditions and with low flow augmentation from Tygart, Youghiogheny, East Branch, and Allegheny Reservoirs and the authorized Rowlesburg and Stonewall Jackson Reservoirs.

TABLE 2

LOW FLOW FREQUENCY DATA

	Allegheny River Kittanning, Pennsylvania cfs	mgd	Allegheny River Natrona, Pennsylvania cfs	mgd	Ohio River Sewickley, Pennsylvania cfs	mgd
Minimum of Record	570	368	922	596	1800	1163
Mean 7 day, 10 year Frequency Low Flow						
Natural	750	484	900	581	1700	1098
Augmented	2300	1485	3000	1938	5000	3230
Mean 7 day, 30 year Frequency Low Flow						
Natural	610	394	720	465	1350	872
Augmented	2050	1324	2700	1744	4400	2840
Mean daily, 30 year Frequency Low Flow						
Natural	529	342	732	473		

Note: Period of record used in above analyses varies.

Economy

Pittsburgh, Pennsylvania, is the most highly populated and largest economic center in the study area. Here the Allegheny and Monongahela Rivers join to form the Ohio River, thus creating a vast potential for heavy water using industries along the three rivers.

Presently, the Pittsburgh area supports various industries, the bulk of which are primary metals production and fabrication, chemical production and research, and clay, stone and glass production. In recent years there has been a trend away from expansion of primary metals production toward the establishment of chemical industries. A recent article in the magazine Chemical Week (1) points out that "Pittsburgh has become Chemical City, with the largest conglomeration of chemical producers, builders and researchers in the country."

The concentration of industry decreases as one travels upstream along the Allegheny River. The portion of Allegheny River in Allegheny and Westmoreland Counties supports a variety of industries the largest of which are primary metal production and fabrication and stone, clay and glass production. In Armstrong County most industries along the Allegheny River are located in the communities of Ford City and Kittanning, Pennsylvania.

Table 3 presents a summary of the number and employment size of manufacturing plants located in the study area.

TABLE 3

NUMBER AND EMPLOYMENT SIZE OF MANUFACTURING PLANTS
(From McGraw-Hill Survey of Industrial Plants, 1964)
(Allegheny, Armstrong, Beaver, Butler, Clarion, Washington and Westmoreland Counties, Pennsylvania)

SIC		20-49	50-99	100-249	250-499	500-999	Over 1000	Total
20	Food and Kindred Products	66	24	20	6	5	1	122
22	Textile Mill Products	3	-	-	-	-	-	3
23	Apparel and Related Products	-	1	5	1	-	-	7
24	Lumber and Wood	-	-	2	-	1	-	3
25	Furniture and Fixtures	2	3	3	1	-	-	9
26	Paper and Allied Products	2	1	9	5	-	-	17
27	Printing and Publishing	-	-	10	2	2	1	15
28	Chemicals and Allied Products	29	8	16	2	1	-	56
29	Petroleum and Coal	1	2	3	3	-	-	9
30	Rubber and Plastics	8	6	2	2	1	-	19
32	Stone, Clay and Glass	9	11	30	12	12	1	75
33	Primary Metals	26	13	21	15	8	31	113
34	Fabricated Metals	63	40	25	14	5	4	151
35	Machinery, except Electrical	53	33	26	7	-	6	125
36	Electrical Machinery	14	9	8	3	3	8	45

SIC		20-49	50-99	100-249	250-499	500-999	Over 1000	Total
37	Transportation Equipment	5	3	2	1	-	4	15
38	Instruments and Related Products	5	7	3	-	-	2	17
39	Miscellaneous	5	5	5	4	-	-	19
	TOTAL	291	165	190	78	38	58	820

Population and industrial employment projections used in the analyses of potential water supply and water quality problems were based upon the developmental benchmark projections disaggregated to the county level by the Corps of Engineers. In analyzing potential problem areas, it was assumed that existing communities would grow at the same rate as indicated by their respective county population benchmarks.

A significant factor relating to the potential growth of large water using industries along the Allegheny River is the availability of flat land or flood plain adjacent to the river. The Allegheny River is relatively narrow as it cuts through the mountains and rolling hills of western Pennsylvania. Most of the suitable, large industrial sites have already been utilized for municipal and industrial growth. The Corps of Engineers, however, has supplied specific, potential sites on which industrial expansion is predicted. These sites range in size from 17 to 138 acres.

The bulk of growth is anticipated as new chemical producing industries. Since many of the potential sites are small in size, new industrial establishments will likewise be limited in production and future expansion.

Table 4 presents a summary of the net employment change from 1962 to 2020, by counties, for the large water using industries.

Table 5 presents the county population projections.

TABLE 4

SUMMARY OF NET EMPLOYMENT CHANGE
FROM 1962 TO 2020 BASED UPON
BENCHMARK PROJECTIONS

Industry	Net Totals	Allegheny	Armstrong	Clarion	Forest	Venango	Warren	Westmoreland
Food	+ 799	-425	+52	+862	-22	0	0	+ 332
Apparel	- 13	+20	0	0	0	-5	-24	-4
Paper	+2157	+465	0	+95	0	-1	0	2/ +1598
Chemicals	+18,449	1/ +11,767	+5918	+318	-9	+307	-33	+181
Petroleum	-1889	-440	-10	-10	0	-1088	-321	-20
Primary Metals	-22,629	-27,818	+1169	+237	+126	+977	+2680	0
Net Totals	-3126	-16,431	+7129	+1502	+95	+190	+2302	+2087

1/ 4613 along Monongahela River; 7154 in Allegheny River

2/ All along Monongahela River

TABLE 5

Benchmark Population Projections

County	1960	1980	2000	2020
Allegheny County	1,628,587	1,667,500	1,940,400	1,981,700
Beaver County	206,948	302,400	438,300	468,900
Washington County	217,271	257,200	325,600	506,100
Westmoreland County	352,629	418,900	532,200	831,000
Clarion County	37,408	56,400	70,000	174,300
Clarion Borough*	4,958	8,800	17,000	57,000
Armstrong County	79,524	82,100	83,900	98,000
Butler County	114,639	170,200	469,000	516,000
TOTAL	2,637,006	2,954,700	3,859,400	4,576,000

*Figures for Clarion Borough are included as a part of the Clarion County figures and should not be included in summation for the total values.

Present Water Use

There are many communities along the Allegheny and Ohio Rivers which obtain their water supplies from either the ground water resources of alluvium deposits or surface sources. Table 6 presents a summary of the major communities which utilize these sources for their water supplies.

The community of Clarion, Pennsylvania, presently obtains its water supply from several wells which have a limited potential yield and the water is of relatively poor quality.

Water is pumped from the Allegheny River in the vicinity of East Brady, Pennsylvania, across the drainage divide to temporary storage reservoirs and used for industrial and municipal water supply at the community of Butler, Pennsylvania. According to the Pennsylvania Department of Forests and Waters, the maximum allowable extraction is presently 5.5 mgd. Since the users are located in the Beaver River basin, this water is never returned to the Allegheny River.

The present industrial complex located along the lower reaches of the Allegheny River and the Ohio River in the vicinity of Pittsburgh, Pennsylvania, is the largest user of water in the study area. Only a small portion of the gross requirements for cooling and process water are lost to the basin as consumptive use. Thus water is reused by the various municipal and industrial users along the Allegheny and Ohio Rivers.

Present Water Quality

A study by the U. S. Geological Survey (2) indicates "the Allegheny River at Kittanning is......generally of good quality and suitable for recreation, domestic use and most industrial purposes after moderate treatment".

TABLE 6

MUNICIPAL WATER USE

Municipality	Source	LOW FLOW mgd 1/		Present	1980	2000	2020
Pittsburgh	Allegheny	473	Pop. Served	700,000	717,000	834,000	852,000
			mgd	96.1	101.8	122.5	129.5
Wilkensburg	Allegheny	473	Pop. Served	250,000	256,000	298,000	304,000
			mgd	19.2	21.0	25.3	26.8
Tarentum	Allegheny	473	Pop. Served	12,000	12,300	14,300	14,600
			mgd	1.4	1.6	1.9	2.0
Oakmont	Allegheny	473	Pop. Served	85,000	87,000	101,200	103,400
			mgd	4.7	5.4	6.7	7.1
Brackenridge	Allegheny	473	Pop. Served	5,200	5,320	6,190	6,330
			mgd	1.5	1.6	1.9	2.0
Kittanning	Allegheny	342	Pop. Served	9,000	9,290	9,500	11,100
			mgd	1.4	1.5	1.6	1.9
Freeport	Allegheny	473	Pop. Served	2,300	2,370	2,430	2,830
			mgd	0.22	0.25	0.27	0.34
Butler	Lake Oneida	2/ 10	Pop. Served	42,000	62,200	172,000	189,000
	Thorn Run Res.		mgd	5.5	8.6	24.7	28.4
	Allegheny River						
Clarion	Wells 3/	1.7	Pop. Served	5,000	8,850	17,150	57,500
	Clarion River	15	mgd	0.53	1.1	2.2	7.7

1/ Mean daily, 30 year frequency low flow under natural conditions.
2/ Includes 5.5 mgd from the Allegheny River. The two reservoirs located in the Connoquenessing drainage have a combined capacity of 890 mgd.
3/ Clarion River could be used as alternate source.

Mineral quality in the Allegheny River at Natrona is influenced by the Kiskiminetas River.

The water quality of the Kiskiminetas River is seriously degraded by acid mine drainage from both active and inactive coal mining operations in the basin. The Allegheny River is therefore degraded to varying degrees depending upon the volume contributed by the Kiskiminetas River. The following analyses of the Allegheny River below the confluence of the Kiskiminetas River indicates the variance of the effect of the Kiskiminetas River on the quality of the Allegheny River.

pH	4.0 to 6.8
specific conductance	340 to 650 micromhos per cm.
hardness	115 to 240 mg/l (as $CaCO_3$)
sulfate	95 to 270 mg/l
manganese	1.6 to 5.2 mg/l

The U.S.G.S. report also states "although the Allegheny River at Natrona may be acidic and contain as much as 430 ppm dissolved solids during low flow, the Pennsylvania Fish Commission reports that the more hardy species of fish survive in the river from Pittsburgh to Freeport - trout and pike excepted". Many of the adverse quality conditions that are characteristic of the river during low flow can be altered by dilution when releases are made from the Allegheny River Reservoir. Experience has taught that when roughly 30 percent of the Allegheny flow originates from the Kiskiminetas River, fish kills can be expected. One million fish were killed in the Allegheny River below the Kiskiminetas, due to acid conditions, from August 19 to 23, 1966. (3) With the Allegheny River Reservoir now

in operation, most of the conditions which resulted in fish kills in the past are less likely to occur since low flow augmentation will increase Allegheny River flows.

A special study by the Wheeling Field Station (4) shows that in the Parker to Kittanning reach of the Allegheny, concentrations of manganese, phenols, biochemical oxygen demand, total iron, total coliform, fecal coliform, and fecal streptococci exceed maximum permissible limits.

The Ohio River at Rochester, Pennsylvania (25.2 miles downstream from confluence of the Allegheny and Monongahela Rivers) was found to have undesirable levels of specific conductance, manganese, sulfates, biochemical oxygen demand, total iron, total coliform, fecal coliform, phenols, surfactants (synthetic detergents), and total phosphate.

The intermittently degraded quality of the Allegheny River in its lower reaches is due largely to mine drainage discharges on its tributaries, especially the Kiskiminetas River and to the municipal and industrial complex in the Pittsburgh metropolitan area. Secondary treatment of municipal wastes and an equivalent degree of treatment for industrial organic wastes would allow the Allegheny River to meet the interstate dissolved oxygen standards adopted by the State of Pennsylvania now pending approval by the Secretary of the Interior.

Pennsylvania has initiated a 10 year acid mine drainage remedial program which should alleviate a large portion of the pollution from inactive mine sources in the Allegheny River basin. Correction of acid mine drainage from active mines is being accomplished through the existing Clean Streams Law.

Desirable water quality can be achieved in the Ohio River at Pittsburgh, under present conditions, by secondary treatment plus disinfection of

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municipal wastes and an equivalent degree of treatment for industrial wastes. Mine drainage in the Monongahela River adversely affects water quality in the Ohio River at Pittsburgh. Pennsylvania's 10 year mine drainage remedial program applies also to the Monongahela River basin. However, it is believed that a Federally funded program will be needed both in West Virginia and Pennsylvania to bring mine drainage pollution under adequate control.

During 1966, the FWPCA conducted a stream water quality survey of the Clarion River area as part of the region-wide Appalachia Water Resources Survey. Special emphasis was given to areas whose water quality was known to be influenced by mine drainage.

The survey found the Clarion River to be discharging an average of 63 tons per day of net acidity to the Allegheny River. Acidity concentrations and pH values ranged from 25 to 40 milligrams per liter (mg/l) and from 4.1 to 5.3, respectively. The maximum alkalinity present in the Clarion River at its mouth was four mg/l. Total iron concentrations were only moderately high, averaging 0.7 mg/l during the survey, but manganese concentrations averaged 3.0 mg/l.

Because the observed alkalinity concentrations are not completely depleted, and, acidity concentrations are only moderately high, the stream's acid-alkaline ratio could be reversed in favor of the alkaline side with a reasonable amount of mine drainage remedial effort. Concentrations of associated mine drainage parameters would likewise be substantially reduced by the remedial effort.

The principal mine drainage problem areas in the Clarion basin are the watersheds of Toby Creek (Clarion County), Licking, Deer, Mill, and Piney Creeks, and, Toby Creek (Jefferson County). These tributaries are largely responsible for the residual water quality effects observed in the lower reach of the Clarion River. An aggregate net acid load of 65 tons per day was discharged to the Clarion River by these six tributaries during the 1966 survey.

The FWPCA and the Pennsylvania Department of Health conducted a cooperative survey during 1967 to locate and quantify the sources of mine drainage in the six tributary problem areas. More than 23 million gallons per day (mgd) of acid drainage was measured flowing from nearly 500 sources. This discharge carried a total acid load of 77 tons to the receiving streams. Less than one percent of the acid load was discharged from active coal mines. (See Appendix I)

A preliminary analysis of the mine drainage source inventory data indicates that physical abatement of about 10 percent of the total number of sources measured would achieve near-alkaline conditions in the lower reach of the Clarion River. Based on flow and water quality conditions at the time of the 1966-67 surveys, physical abatement of 45 discharges (at assumed abatement efficiencies for each source) would reduce the acidity content of the Clarion River near its mouth by about 75 percent.

The mine drainage source inventory work disclosed that, in the Licking and Mill Creek watersheds, acid discharged from abandoned gas wells is an additional, very sizeable source of stream water quality degradation. Abatement of some of these sources is desirable to complement acid reductions from coal mine sources. Complete data regarding gas well locations and discharge characteristics is not available at this time.

Achievement of the 75 percent reduction of the acid load in the lower Clarion River, through source abatement, would result in decreased acidity concentrations and increased alkalinity concentrations. Resultant acidity levels through reductions effected from stream conditions measured in 1966 in the lower Clarion River would be less than 10 mg/l. Corresponding pH values are expected to be neutral. Attendant reductions in concentrations of mine drainage-related constituents should result in acceptable levels for most water uses.

Water Quality Objectives

The State of Pennsylvania has submitted proposed water quality standards and an implementation plan in accordance with the Federal Water Pollution Control Act of 1965. These standards, applying to interstate waters, are currently under review.

Pennsylvania has established the following uses to be protected in the Allegheny River from Redbank Creek to Pittsburgh: warm water fish, domestic and industrial water supply, livestock and wildlife watering, irrigation, boating, fishing, water contact sports, natural area, power, navigation and treated waste assimilation.

To protect these uses, the following criteria have been proposed:

Allegheny River from the Kiskiminetas River to the Mouth

pH - not less than 6.0; not more than 8.5

Dissolved Oxygen - minimum daily average 5.0 mg/l; no value less than 4.0 mg/l

Total iron - not to exceed 1.5 mg/l

Temperature - not to exceed 5° F rise above ambient temperature or a maximum of 87° F whichever is less; not to be changed by more than 2° F during any one hour period.

Dissolved Solids - not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time.

Threshold Odor Number - not to exceed 24 at 60° C

Total Manganese - not to exceed 1.0 mg/l

Allegheny River from Redbank Creek to the Kiskiminetas River

Same as above except delete criteria for threshold odor number and total manganese.

For the Ohio River from Pittsburgh to the State line, Pennsylvania has established the same uses as in the lower Allegheny. Criteria proposed to protect these uses are the same as those proposed for the lower Allegheny with the addition of fluoride not to exceed 1.0 mg/l and phenol not to exceed 0.005 mg/l.

Pennsylvania's implementation plan for Allegheny River calls for primary treatment from Redbank Creek to the Kiskiminetas River and "intermediate" treatment from the Kiskiminetas River to the mouth. For the Ohio River from Pittsburgh to the State line, secondary treatment is required although present stream classification calls for primary treatment in Beaver County and intermediate treatment in Allegheny County. Table 7 presents the present status of municipal sewerage facilities in the study area.

Present FWPCA policy calls for a minimum of secondary treatment for all biodegradable wastes with an equivalent high degree of treatment for other wastes. Minor changes in criteria may be required at some future time.

TABLE 7

MUNICIPAL SEWERAGE FACILITIES

Municipality	Present Population Served	Present Treatment*	Receiving Stream	Mile Point
Emlenton	844	P	Allegheny River	92
Foxburg	383	None	Allegheny River	88
Parker	950	None	Allegheny River	84
East Brady	2734	None	Allegheny River	69
Templeton	900	None	Allegheny River	54
Kittanning	6790	P-C	Allegheny River	44
West Kittanning	1200	None	Allegheny River	44
Applewold	490	None	Allegheny River	44
Ford City	6000	P-C	Allegheny River	41
Freeport	2430	P-C	Allegheny River	29
U.A.J.S.A.	8230	I-C	Allegheny River	21
New Kensington	23,500	I-C	Allegheny River	18
A.V.J.S.A.	12,000	I-C	Allegheny River	13
Al.Co.San.A.	1,250,000	I-C[1/]	Ohio River	3.2
Oakmont	8,000	I-C	Allegheny River	12

TABLE 7 (continued)

Municipality	Present Population Served	Present Treatment	Receiving Stream	Mile Point
Corapolis	23,800	I-C	Ohio River	10
Sewickley	6766	I-C	Ohio River	12

*P - Primary I - Intermediate C - Chlorination

1/ BOD_5 removal normally less than 50%

Water Supply Needs

The present and projected individual municipal and industrial water supply requirements were compared to the existing low flow conditions of the supply source. Those users who obtain their supplies from existing navigation pools are guaranteed an adequate supply; if water needs exceed river flow, the water is merely reused.

The largest single user of Allegheny River water by the year 2020 is expected to be the city of Pittsburgh, Pennsylvania. Its projected total requirement of 130 million gallons per day (mgd) will exceed that of any other potential single municipal or industrial user along the Allegheny River. The existing water resources of the Allegheny River are more than adequate to meet this projected requirement.

Projected water requirements of Clarion, Pennsylvania, exceed the estimated reliable yield of their present source. Therefore, the community will probably change its source and obtain water from the Clarion River. The low flow conditions of the Clarion River are sufficient to meet the projected needs of the area.

The community of Butler, Pennsylvania, will need to obtain additional amounts of water from sources other than the Connoquenessing Creek in order to meet projected water needs. The present water withdrawal from the Allegheny River is limited to 5.5 mgd, or 0.5 percent of the existing reliable flow. If all of the projected additional water needs were met from the Allegheny River, the withdrawal rate would increase to 2.5 percent of the existing reliable flow; thus, present streamflow conditions are adequate.

In summary, it appears that the existing reliable streamflow, with Allegheny River Reservoir in operation, is adequate to meet the projected municipal and industrial water supply requirements of the study area.

Water Quality Control Needs

An analysis of total streamflow needed to maintain proper assimilation of organic wastes, assuming secondary treatment at the waste source, was made on the Allegheny and Ohio Rivers. The major rivers of the study area were divided into reaches in order to better assess the accumulative effect of projected municipal and industrial wastes on stream dissolved oxygen.

Water quality control flows are based on the collection and treatment of all wastes. Maintenance of suitable water quality requires that at least 85 percent of the waste load, as measured by the five day Biochemical Oxygen Demand, is removed; that all settleable solids that will form putrescent or otherwise objectionable sludge deposits are removed; that oil scum, floating materials, and substances producing color and odor are removed to such degrees required to prevent unsightly or deleterious conditions; that all substances that are toxic or harmful to human, animal, plant or aquatic life by themselves or in combination are removed; that heated discharges will be sufficiently cooled before discharge to prevent stream impairment for other uses; and that harmful bacteria will be reduced in sufficient number to allow intended stream uses.

The present streamflow conditions of the Allegheny River can adequately provide proper assimilation of treated municipal and industrial wastes under present and projected conditions. The greatest concentration of organic waste loads is projected to occur in the lower reaches of the Allegheny River.

There is a need for low flow augmentation for water quality control in Connoquenessing Creek near Butler, Pennsylvania. This creek is presently

degraded by residual municipal and industrial wastes in that high nutrient levels cause serious algal blooms; also, during low flow periods the stream lacks sufficient capacity for proper waste assimilation. Alternative methods of pollution control must be considered in order to provide the most feasible solution to the problem. Since the surface water storage potential of the Connoquenessing Creek watershed is inadequate to meet the projected storage requirement needs, either complete treatment of wastes or surface storage outside the basin must be considered. If a suitable quality of water is impounded, the community of Butler, Pennsylvania, after studying the feasibility of such alternatives, may be interested in purchasing storage in the proposed St. Petersburg Reservoir for low flow augmentation. This could be accomplished by expanding the existing water conveyance system from the Allegheny River.

The Ohio River near Pittsburgh, Pennsylvania, will need additional streamflow to insure proper assimilation of projected (2020) municipal and industrial residual waste loads after treatment. The present scheme of existing and authorized reservoirs will not provide sufficient storage to satisfy future streamflow needs for water quality control. The inclusion of storage for water quality control in the proposed St. Petersburg Reservoir is contingent on improvement in existing water.

Population growth and the expected increase in industrial production, primarily in the chemical field as indicated by the benchmark projections, will tax the assimilative capacity of the Ohio River. Total flow requirements for quality control below Pittsburgh, Pennsylvania, as measured at the U.S.G.S. gage at Sewickley are as follows:

Projected Total Streamflow Requirements (cfs)
on the Ohio River at Sewickley, Pennsylvania

	1980	2000	2020
January	3800	4400	5250
February	3950	4550	5400
March	4150	4800	5700
April	4550	5300	6250
May	4950	5750	6800
June	5500	6350	7500
July	5700	6600	7800
August	5600	6450	7650
September	5300	6150	7250
October	4700	5450	6450
November	4200	4850	5750
December	3950	4550	5400

The Corps of Engineers, Pittsburgh District has completed several computer analyses of reservoir operation studies for the proposed St. Petersburg Reservoir. These analyses show the effects of reservoir regulation on streamflow conditions in the Allegheny and Ohio Rivers during the period 1929 to 1966. Results indicate that 110,000 acre feet of storage would be needed in the proposed St. Petersburg Reservoir to satisfy the projected total flow requirements by the year 2020 for nine out of ten years. This storage amount is based upon conditions as follows:

a. Existing reservoirs are operated according to original release schedules.

b. The authorized Rowlesburg Reservoir, which has 572,000 acre feet storage for water quality control, is in place and operated for low flow augmentation needs at Lock 2, Monongahela River.

c. The proposed St. Petersburg Reservoir has a total summer storage potential of 685,000 acre feet for recreation and water quality control.

As a prerequisite to inclusion of storage for water quality control in the proposed St. Petersburg Reservoir, the quality of the Clarion River must be improved by corrective measures applied to the existing coal mine drainage sources. Storage of water of the present quality of the Clarion River would be of little value for anticipated water quality control needs on the Ohio River at Pittsburgh, Pennsylvania, and, water oriented recreational usage would be restricted. Also, experience has shown that reservoirs constructed in areas affected by coal mine drainage may become progressively acidic.

Analyses of available stream quality and mine drainage source data indicates that water quality of the Clarion River could be enhanced to an acceptable level through a reasonable amount of mine drainage source abatement. Drainage abatement by physical construction measures at a minimum of 40 coal mining sites, five known abandoned gas well sites, and an additional undetermined number of abandoned gas and/or oil well sites, upstream of the St. Petersburg site, is expected to result in a significant water quality improvement in the lower Clarion River. On the average, it is expected that resultant acidity concentrations in the proposed reservoir area would be less than 10 mg/l, alkalinity concentrations would be greater than 10 mg/l, and pH values would be above 6.0. Attendant reductions in concentrations of mine drainage-related constituents should result in acceptable levels for most water uses.

Abatement costs for 45 principal acid sources upstream of the reservoir site are estimated, on a preliminary basis, at $3.0 million. (See Appendix I.)

A detailed engineering study is required to determine specific construction measures and costs at each site.

It is recommended that provision be made to include a proposed mine drainage source abatement program, at least as extensive as outlined in Appendix I, as an integral part of the proposed reservoir project.

Benefits

The low flow augmentation needs on the Ohio River at Pittsburgh, Pennsylvania can be met by construction of a single purpose reservoir containing 110,000 acre feet of storage for water quality control. Such a reservoir would be the least costly alternative method to solve projected quality problems.

Based upon reservoir cost estimates provided by the Corps of Engineers, Pittsburgh District, benefits are assessed as follows:

Total Construction Cost	O & M Annual Cost	Total Annual Cost 1/
$27,500,000	$69,000	$1,001,000

1/ Includes annual operation and maintenance costs.

Total annual cost was developed from annual operation and maintenance cost plus a 100 year amortization of capital costs at an interest rate of 3 1/4 percent. This average annual cost of a single purpose alternate reservoir for water quality control is considered to be the minimum benefits associated with meeting the needs from storage in the Allegheny basin.

Computations indicate that this additional storage will be required to meet low flow augmentation needs at Pittsburgh by the year 1980. It is estimated that actual construction of facilities to provide this storage could not be completed prior to the initial time of need. The benefits, therefore, were not discounted to reflect a time lag between completion of construction and initial flow augmentation needs.

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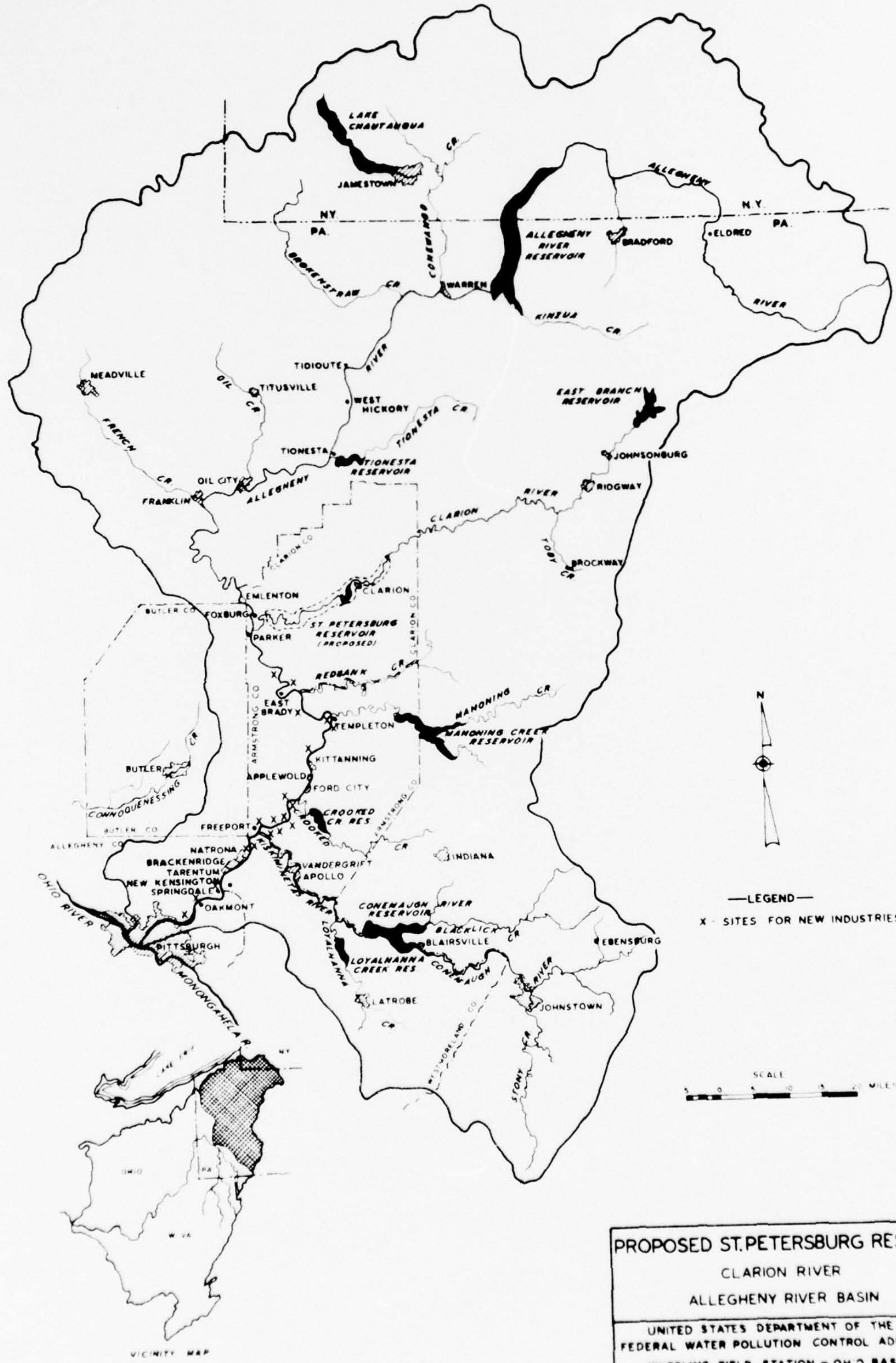


PROPOSED ST. PETERSBURG RESERVOIR

CLARION RIVER

ALLEGHENY RIVER BASIN

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
WHEELING FIELD STATION - OHIO BASIN REGION

FIGURE 1

APPENDIX I

CLARION RIVER BASIN

MINE DRAINAGE SOURCE INVESTIGATION

FWPCA

WHEELING FIELD STATION

MINE DRAINAGE SOURCE INVESTIGATION

TOBY CREEK WATERSHED (JEFFERSON COUNTY) SUMMARY

Drainage Area:	125 square miles
Location:	Clarion River Milepoint 80.2
Net Acid Load 1/ 2/ (at mouth):	14,936 lbs./day
Number of Sources Investigated:	185
Number of Sources Discharging:	113
Total Source Acid Load Measured:	38,089 lbs./day
Major Acid Load Source Category:	Underground mines
Principal Sources:	Mine numbers 920, 921, 926, 939, 954, 958, 960, 946, 984, 996, 998, 1187
Preliminary Abatement Cost Estimate, Principal Sources:	$200,000

Remarks: Three active drift mines in the watershed discharged a total acid load during the survey of only 143 lbs./day. All other discharges measured were from inactive or abandoned mine sites.

The acid load of the 12 principal sources totals 30,045 lbs./day, about 80 percent of the total watershed source load measured. Pertinent data regarding the principal sources is given in the following table:

1/ Acid Load Minus Alkaline Load.
2/ Average of Six Samplings, 1966.

PRINCIPAL SOURCES

	Mine No.	Type	Receiving Stream	Flow (gpm)	pH	Specific Conductance	Acidity mg/l	Acidity lbs/day
1.	920	Drift	Limestone Run	387	2.9	1650	765	3,553
2.	921	Drift	Limestone Run	387	2.9	1500	545	2,531
3.	926	Drift	Toby Creek	180	3.0	1500	730	1,577
4.	939	Strip-(Comb.)*	Kyler Run	380	3.9	1400	310	1,410
5.	954	Deep	Kyler Run	90	2.6	3000	1455	1,555
6.	958	Deep (Comb.)**	Unnamed Trib.	170	5.5	2200	490	1,000
7.	960	Drift	Toby Creek	400	3.5	1200	315	1,512
8.	946	Drift-(Comb.)	Kyler Run	1323	3.2	1300	300	4,761
9.	984	Drift	Unnamed Trib.	635	4.6	1600	465	3,543
10.	996	Drift-(Comb.)	Unnamed Trib.	1152	2.8	1200	290	4,009
11.	998	Drift	Brandy Camp Cr.	220	3.1	1400	390	1,030
12.	1187	Drift	Toby Creek	440	2.8	2500	675	3,564
							TOTAL	30,045

*Combination Strip Mine. Strip and underground mines together with principal portion of discharge from the strip mine.

**Combination Underground Mine. Strip and underground mines together with principal portion of discharge from the underground mine.

If physical abatement measures were constructed to achieve drainage quality control at the 12 sites indicated, Toby Creek (Elk and Jefferson Counties) could discharge only a very minor acid load to the Clarion River.

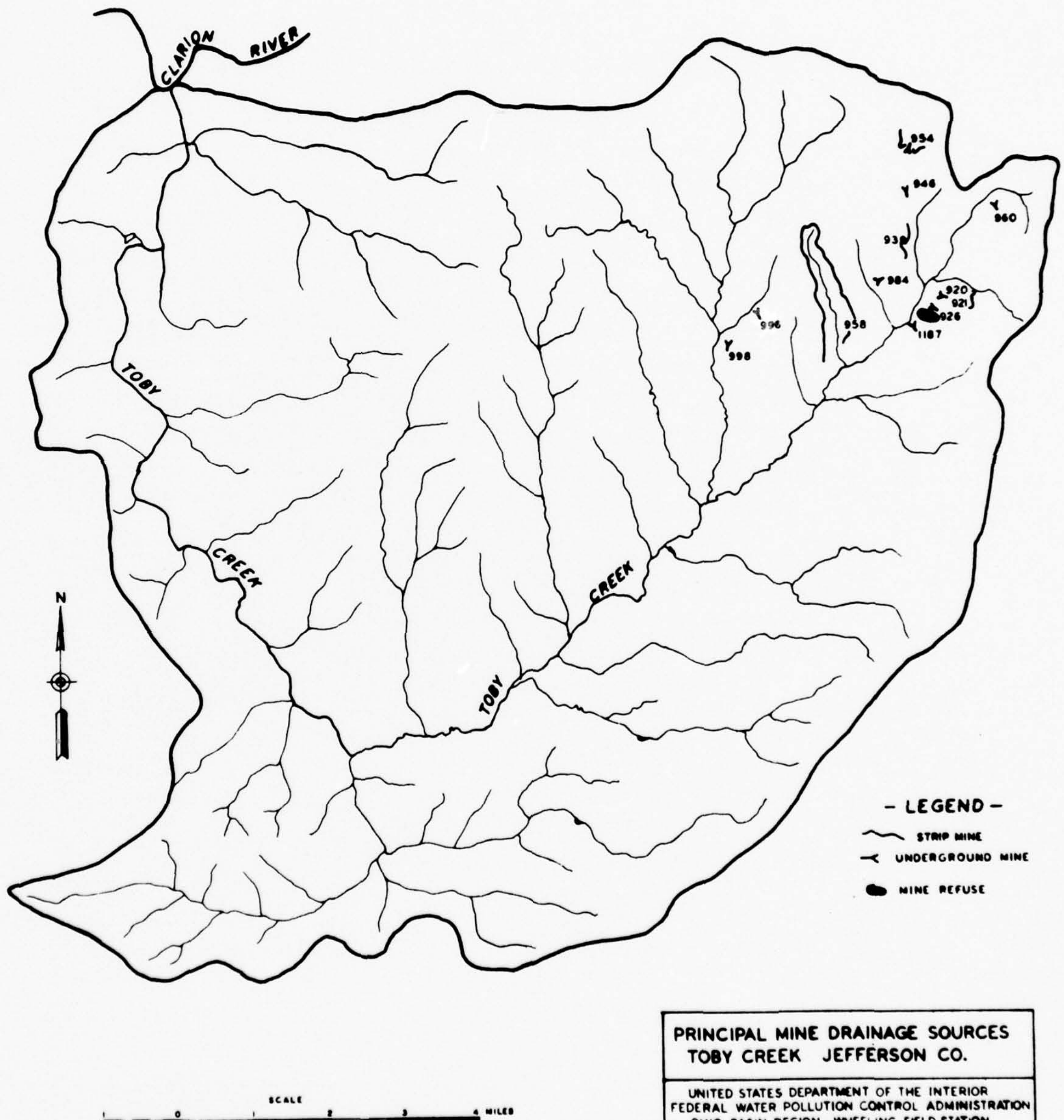
If an overall 50 percent reduction in acid discharge from these 12 sites could be achieved by the mine sealing and related construction, their total load would be cut to 15,000 lbs./day acidity. This load is just about the cumulative residual load measured at the mount of Toby Creek. If only 25-30 percent reductions were possible, the watershed acid contribution to the Clarion would be reduced by at least one-half.

Although Clarion River pollution from this watershed is far removed from the proposed reservoir boundaries, acid drainage reduction in Toby Creek would bequeath a greater alkaline reserve to the Clarion which would enable it to assimilate larger acid loads downstream.

The above mine sites selected for acid drainage abatement are suggested to achieve the minimum effect of reducing or eliminating the cumulative acid load residual at the mouth of the watershed. Abatement of polluted conditions in the entire watershed or any portions thereof would be a much larger task.

A gross preliminary estimate of the cost of physical measures to control or reduce the pollutant effect of the 12 principal sources in $200,000. A detailed engineering study is required to determine feasible construction measures and costs at each site.

The locations of the 12 principal sources in the Toby Creek (Jefferson County) watershed are shown on Figure 2.



PRINCIPAL MINE DRAINAGE SOURCES
TOBY CREEK JEFFERSON CO.

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION WHEELING FIELD STATION

FIGURE 2

FWPCA

WHEELING FIELD STATION

MINE DRAINAGE SOURCE INVESTIGATION

TOBY CREEK WATERSHED (CLARION COUNTY) SUMMARY

Drainage Area:	37 square miles
Location:	Clarion River Milepoint 30.0
Net Acid Load (at mouth) 1/ 2/:	47,582 lbs./day
Number of Sources Investigated:	99
Number of Sources Discharging:	81
Total Source Acid Load Measured:	79,784 lbs./day
Major Acid Load Source Category:	Strip mines
Principal Sources:	Mine numbers 1015, 1023, 1029, 1031, 1040, 1044, 1058
Preliminary Abatement Cost Estimate, Principal Sources:	$350,000

Remarks: Active mines in the watershed (strip mines) were not contributing acid drainage to streams at the time of the survey. One operation was discharging alkaline water.

The acid load of the seven principal sources totals 72,494 lbs./day, about 90 percent of the total watershed source load measured. Pertinent data regarding the principal sources is given in the following table:

1/ Acid Load Minus Alkaline Load.
2/ Average of Six Samplings, 1966.

PRINCIPAL SOURCES

	Mine No.	Type	Receiving Stream	Flow (gpm)	pH	Specific Conductance	Acidity mg/l	Acidity lbs/day
1.	1015	Drift-(Comb.)*	Unnamed Trib.	207	3.4	1050	465	1155
2.	1023	Strip	Toby Creek	500	2.7	9000	8330	49,980
3.	1029	Strip	Rapp Run	60	2.8	8250	7600	5,472
4.	1031	Strip	Rapp Run	65	2.8	7000	6365	4,965
5.	1040	Strip	Unnamed Trib.	65	2.9	3000	6200	4,836
6.	1044	Strip	Unnamed Trib.	45	2.8	7800	7380	3,985
7.	1058	Strip	Unnamed Trib.	45	2.5	3000	3890	2,101
							TOTAL	72,494

*Combination Drift Mine. Strip and drift mines together with principal portion of discharge from the drift mine.

If physical abatement measures were imposed at these seven areas of the total 81 source areas surveyed, Toby Creek could be an alkaline stream at its confluence with the Clarion River.

Since six of the seven sources are of surface mine origin, a resultant high percentage reduction in acid load from each would be expected after application of known abatement or reclamation techniques. Assuming an overall acid load reduction of about 75 percent, the cumulative residual acid load discharged to the Clarion River should be at or near zero on the average.

Acid load fluctuations after source abatement would result through the year as a function of hydrologic conditions. However, the stream's

FWPCA

WHEELING FIELD STATION

MINE DRAINAGE SOURCE INVESTIGATION

TOBY CREEK WATERSHED (CLARION COUNTY) SUMMARY

Drainage Area:	37 square miles
Location:	Clarion River Milepoint 30.0
Net Acid Load (at mouth):[1/] [2/]	47,582 lbs./day
Number of Sources Investigated:	99
Number of Sources Discharging:	81
Total Source Acid Load Measured:	79,784 lbs./day
Major Acid Load Source Category:	Strip mines
Principal Sources:	Mine numbers 1015, 1023, 1029, 1031, 1040, 1044, 1058
Preliminary Abatement Cost Estimate, Principal Sources:	$350,000

Remarks: Active mines in the watershed (strip mines) were not contributing acid drainage to streams at the time of the survey. One operation was discharging alkaline water.

The acid load of the seven principal sources totals 72,494 lbs./day, about 90 percent of the total watershed source load measured. Pertinent data regarding the principal sources is given in the following table:

1/ Acid Load Minus Alkaline Load.
2/ Average of Six Samplings, 1966.

PRINCIPAL SOURCES

	Mine No.	Type	Receiving Stream	Flow (gpm)	pH	Specific Conductance	Acidity mg/l	Acidity lbs/day
1.	1015	Drift-(Comb.)*	Unnamed Trib.	207	3.4	1050	465	1155
2.	1023	Strip	Toby Creek	500	2.7	9000	8330	49,980
3.	1029	Strip	Rapp Run	60	2.8	8250	7600	5,472
4.	1031	Strip	Rapp Run	65	2.8	7000	6365	4,965
5.	1040	Strip	Unnamed Trib.	65	2.9	3000	6200	4,836
6.	1044	Strip	Unnamed Trib.	45	2.8	7800	7380	3,985
7.	1058	Strip	Unnamed Trib.	45	2.5	3000	3890	2,101
							TOTAL	72,494

*Combination Drift Mine. Strip and drift mines together with principal portion of discharge from the drift mine.

If physical abatement measures were imposed at these seven areas of the total 81 source areas surveyed, Toby Creek could be an alkaline stream at its confluence with the Clarion River.

Since six of the seven sources are of surface mine origin, a resultant high percentage reduction in acid load from each would be expected after application of known abatement or reclamation techniques. Assuming an overall acid load reduction of about 75 percent, the cumulative residual acid load discharged to the Clarion River should be at or near zero on the average.

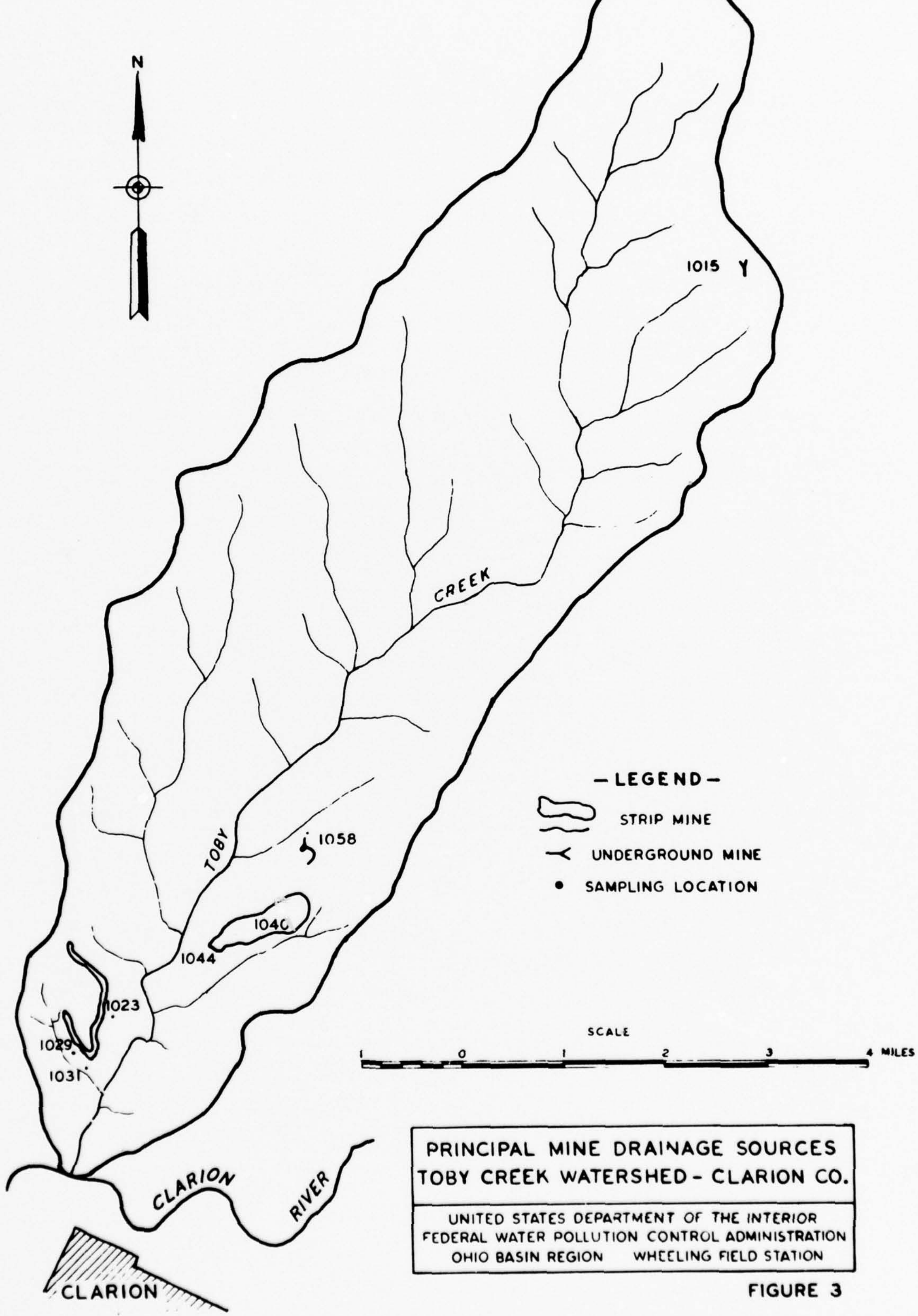
Acid load fluctuations after source abatement would result through the year as a function of hydrologic conditions. However, the stream's

maximum acid discharge under the most adverse hydrologic conditions would be expected to be a fraction of the present situation.

The above mine sites selected for acid drainage abatement are suggested to achieve the minimum effect of reducing or eliminating the cumulative acid load residual at the mouth of the watershed. Abatement of polluted conditions in the entire watershed or portions thereof would be a much larger task.

A gross preliminary estimate of the cost of physical measures to control or reduce the pollutant effect of the seven principal sources is $350,000. A detailed engineering study is required to determine feasible construction measures and costs at each site.

The locations of the seven principal sources in the Toby Creek (Clarion County) watershed are shown on Figure 3.



PRINCIPAL MINE DRAINAGE SOURCES
TOBY CREEK WATERSHED - CLARION CO.

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION WHEELING FIELD STATION

FIGURE 3

FWPCA

WHEELING FIELD STATION

MINE DRAINAGE SOURCE INVESTIGATION

PINEY CREEK WATERSHED SUMMARY

Drainage Area:	70 square miles
Location:	Clarion River Milepoint 21.6
Net Acid Load 1/ (at mouth) 2/:	19,272 lbs./day
Number of Sources Investigated:	130
Number of Sources Discharging:	75
Total Source Acid Load Measured:	10,995 lbs./day
Major Acid Load Source Category:	Strip mines
Principal Sources:	Mine numbers 1173, 4208, 4216
Preliminary Abatement Cost Estimate, Principal Sources:	$150,000

Remarks: Two active strip mines in the watershed were discharging a combined acid load of 1000 lb./day during the survey.

The acid load of the three principal sources totals 3,157 lbs./day, about 29 percent of the total watershed source load measured. Pertinent data regarding the principal sources is given in the following table:

PRINCIPAL SOURCES

	Mine No.	Type	Receiving Stream	Flow (gpm)	pH	Specific Conductance	Acidity mg/l	Acidity lbs./da
1.	1173	Strip	Unnamed Trib.	252	2.9	2150	510	1542
2.	4208*	Strip	Unnamed Trib.	12	3.2	8000	5965	859
3.	4216	Strip	Unnamed Trib.	180	4.5	1800	350	756
							TOTAL	3157

*Some active stripping in area at time of survey.
1/ Acid Load Minus Alkaline Load.
2/ Average of Six Samplings, 1966.

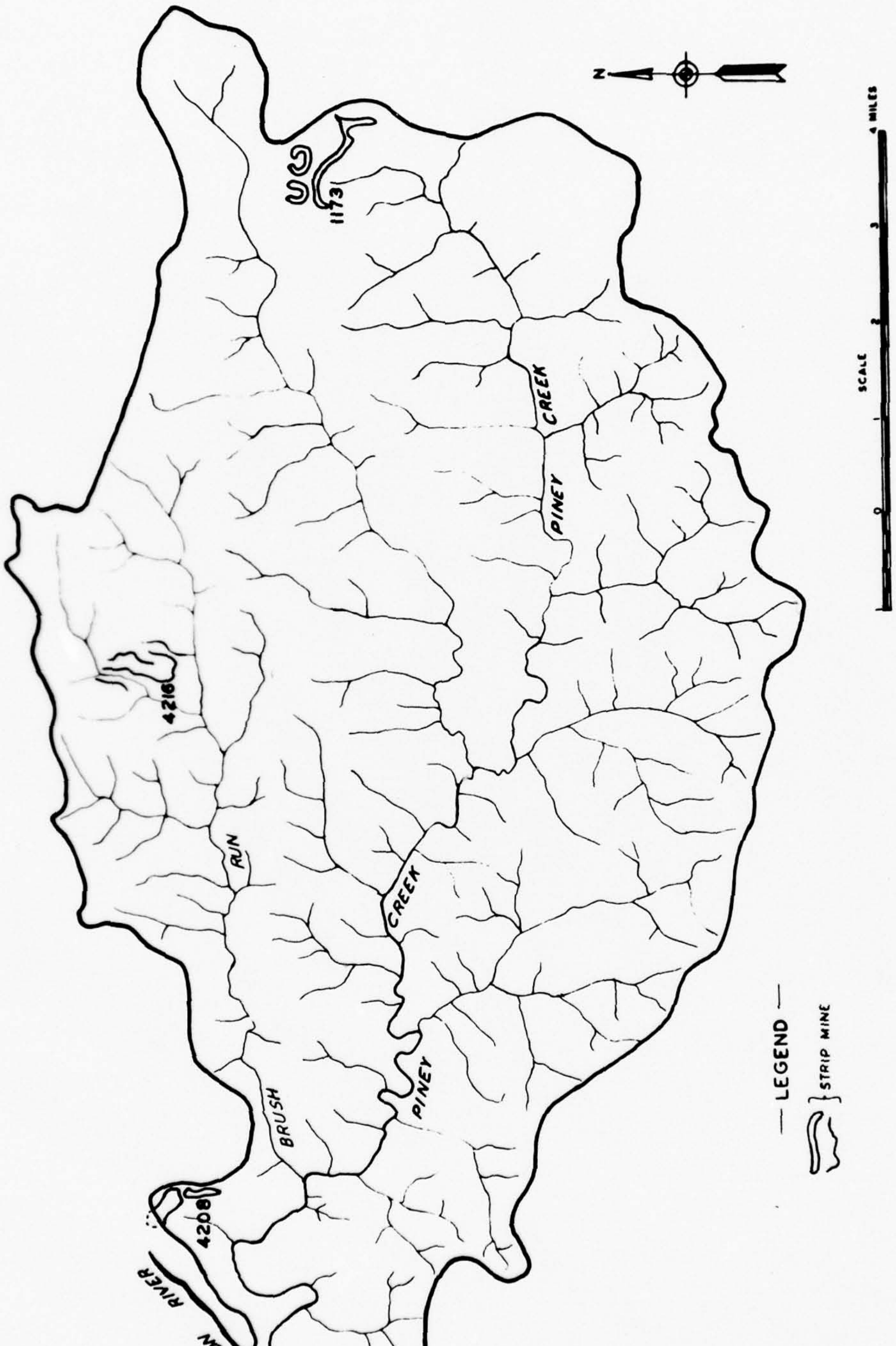
At the time of the mine drainage source investigation (low flow conditions), Piney Creek discharged an acid load of only 1,638 lbs/day. However, the 1966 stream survey, conducted under varying flow conditions, measured an average Piney Creek discharge of 19,272 lbs./day. Based on the acid loading at the low flow condition measured (1,638 lbs./day), elimination of the three listed principal sources would result in alkaline conditions at the mouth of Piney Creek.

The limited stream data indicate that abatement of additional sources may be necessary to effect alkaline conditions at greater than low flow or base flow stream conditions.

The above mine sites selected for acid drainage abatement are suggested to achieve the minimum effect of reducing or eliminating the cumulative acid load residual at the mouth of the watershed. Abatement of polluted conditions in the entire watershed or any portions thereof would be a much larger task.

A gross preliminary estimate of the cost of physical measures to control or reduce the pollutant effect of the three principal sources is $150,000. A detailed engineering study is required to determine feasible construction measures and costs at each site.

The locations of the three principal sources in the Piney Creek watershed are shown on Figure 4.



PRINCIPAL MINE DRAINAGE SOURCES
PINEY CREEK WATERSHED

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION WHEELING FIELD STATION

FIGURE 4

FWPCA

WHEELING FIELD STATION

MINE DRAINAGE SOURCE INVESTIGATION

MILL CREEK WATERSHED SUMMARY

Drainage Area:	56 square miles
Location:	Clarion River Milepoint 35.0
Net Acid Load (at mouth):[1/] [2/]	16,960 lbs./day
Number of Sources Investigated:	26
Number of Sources Discharging:	18
Total Source Acid Load Measured:	6,805 lbs./day
Major Acid Load Source Category:	Strip Mines
Principal Sources:	Mine numbers 4242, 4284, 4356, 4357
Preliminary Abatement Cost Estimate, Principal Sources:	$780,000

Remarks: No active mine discharges existed in the watershed at the time of the survey.

The acid load of the four principal sources totals 6,382 lbs./day, about 94 percent of the total watershed source load measured. Pertinent data regarding the principal sources is given in the following table:

1/ Acid Load Minus Alkaline Load.
2/ Average of Six Samplings, 1966.

PRINCIPAL SOURCES

	Mine No.	Type	Receiving Stream	Flow (gpm)	pH	Specific Conductance	Acidity mg/l	Acidity lbs/day
1.	4242	Strip	Unnamed Trib.	30	4.0	2800	883	318
2.	4284	Strip	Unnamed Trib.	95	3.2	5000	3740	4264
3.	4356	Strip	Jones Run	60	3.4	2800	1260	907
4.	4357	Strip	Jones Run	80	3.4	2000	930	893
							TOTAL	6382

Mill Creek discharged to the Clarion River a net acid load of 16,960 lbs./day during the 1966 survey. The mine drainage source investigation measured 6,805 lbs./day of acid being discharged from 16 strip mines in the watershed. (A small acid load was also measured from two abandoned gas wells.)

The stream survey measured some 10,000 lbs./day of acid in Mill Creek that is not accounted for in the source inventory. This large difference between the values is believed to be the result of abandoned oil and gas well discharges in the basin, similar to coal mine discharges in chemical character, that were not documented in the source investigation survey.

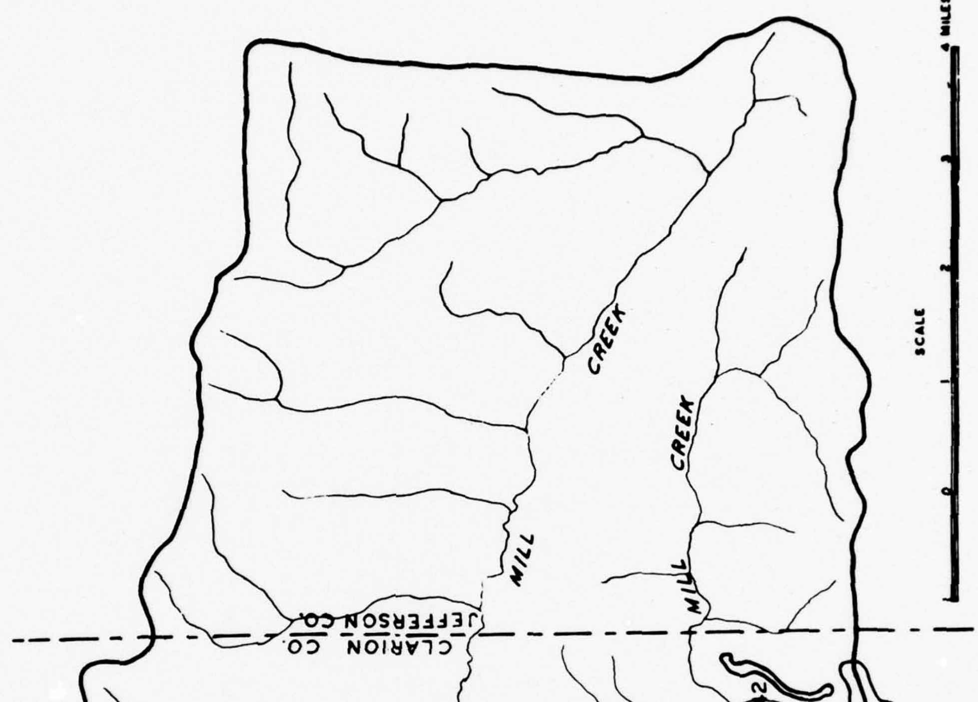
Because of the acid present in Mill Creek that is of an assumed origin, the number of sources needed to be abated to eliminate the acid load discharged to the Clarion River is not available at this time. An additional field survey to locate and quantify the oil and gas well sources would be required to develop this data.

Complete elimination of drainage from the four strip mine areas listed as principal sources would effect an approximate 38 percent reduction in

acidity discharged to the Clarion River. It is expected that plugging or other suitable physical measures employed at the abandoned oil and/or gas wells that are yet to be investigated will result in zero or near-zero acidity discharged to the Clarion River from this watershed.

A gross preliminary estimate of the cost of physical measures to control or reduce the pollutant effect of the four principal sources is $780,000. A detailed engineering study is required to determine feasible construction measures and costs at each site.

The locations of the four principal sources in the Mill Creek watershed are shown on Figure 5.



PRINCIPAL MINE DRAINAGE SOURCES
MILL CREEK WATERSHED

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION - WHEELING FIELD STATION

FIGURE 5

FWPCA

WHEELING FIELD STATION

MINE DRAINAGE SOURCE INVESTIGATION

LICKING CREEK WATERSHED SUMMARY

Drainage Area:	52 square miles
Location:	Clarion River Milepoint 14.8
Net Acid Load (at mouth): 1/ 2/	16,850 lbs./day
Number of Sources Investigated:	212
Number of Sources Discharging:	130
Total Source Acid Load Measured:	6,670 lbs./day
Major Acid Load Source Category:	Strip mines, underground mines
Principal Sources:	Mine numbers 1227, 4314, 4317, 4476, 4477, 4485, 4491, 4564, 4566, 4567, 4568, 4572, 4599.
Preliminary Abatement Cost Estimate, Principal Sources:	$950,000

Remarks: One active drift mine discharged a daily acid load of 103 pounds in the watershed at the time of the survey. All other measured discharges were from inactive or abandoned sites.

The daily acid load of the 13 principal sources totals 4,059 pounds, about 60 percent of the total watershed source load measured. Pertinent data regarding the principal sources is given in the following table:

1/ Acid Load Minus Alkaline Load.
2/ Average of Six Samplings, 1966.

PRINCIPAL SOURCES

	Mine No.	Type	Receiving Stream	Flow (gpm)	pH	Specific Conductance	Acidity mg/l	Acidity lbs/day
1.	1227	Strip	Cherry Run	40	6.6	2750	410	197
2.	4314	Strip	Unnamed Trib.	4	2.8	6000	5070	243
3.	4317	Drift	Licking Creek	15	3.0	5000	1930	347
4.	4476	Drift-Comb.	Unnamed Trib.	85	3.1	1950	365	372
5.	4477	Drift-Comb.	Unnamed Trib.	85	3.3	2100	440	449
6.	4485	Strip	Little Licking Cr.	25	3.3	3600	1425	428
7.	4491	Gas Well	Little Licking Cr.	12	4.4	6500	4635	667
8.	4564	Strip	Anderson Run (Est.)	8	2.9	3800	1610	155
9.	4566	Drift	Unnamed Trib.	35	3.9	1900	470	197
10.	4567	Drift	Mineral Run	30	3.0	3800	970	349
11.	4568	Drift	Mineral Run	15	3.0	3000	1295	214
12.	4572	Strip	Mineral Run	5	3.5	6000	3220	199
13.	4599	Strip	Anderson Run	8	3.2	6000	2525	242
							TOTAL	4059

*Combination Drift Mine. Strip and drift mines together with principal portion of discharge from the drift mine.

Licking Creek discharged a net acid loading to the Clarion River of 16,850 lbs./day during the 1966 survey. The mine drainage source investigation measured 6667 lbs./day being discharged from the 129 coal mine sources and one abandoned gas well in the watershed.

The stream survey measured some 10,000 lbs./day of acid in Licking Creek that is not accounted for in the source inventory. This large difference

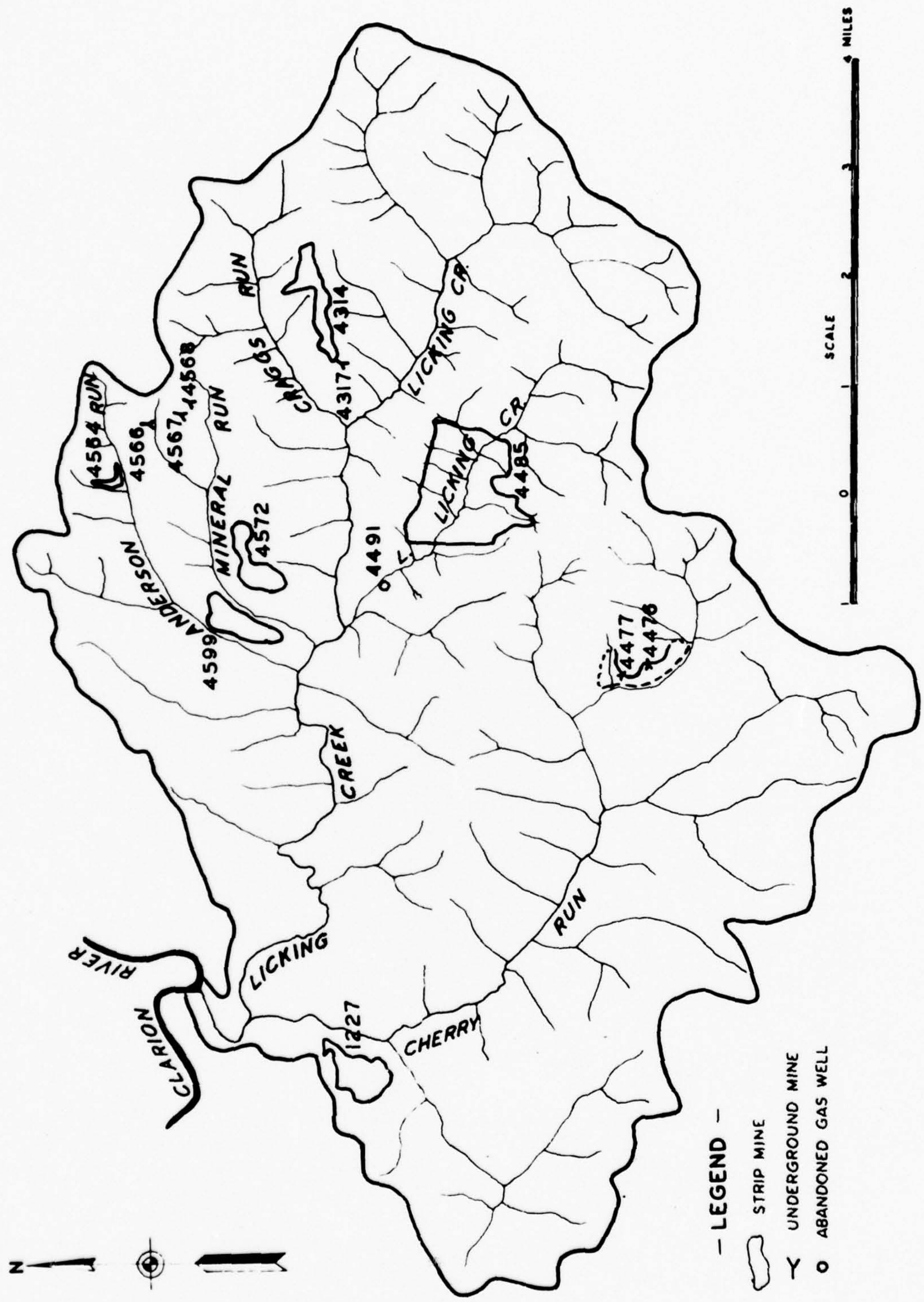
between the values is believed to be the result of abandoned oil and gas well discharges in the basin, similar to coal mine discharges in chemical character, which were not documented in the source investigation survey.

Because of the acid present in Licking Creek that is of an assumed origin, the absolute number of sources needed to be abated to eliminate the acid load discharged to the Clarion River is not available at this time. An additional field survey to locate and quantify the oil and gas well sources would be required to develop this data.

Assuming complete elimination of gas well and strip mine discharges, and a 50 percent reduction of acid load from drift mine discharges, physical abatement of the 13 listed principal sources would reduce the acidity entering the Clarion River from this watershed only about 17 percent. It is expected that plugging or other suitable physical measures employed at the abandoned oil and/or gas wells that are yet to be investigated, will result in zero or near-zero acidity discharged to the Clarion River from this watershed.

A gross preliminary estimate of the cost of physical measures to control or reduce the pollutant effect of the 13 principal sources is $950,000. A detailed engineering study is required to determine feasible construction measures and costs at each site.

The locations of the 13 principal sources in the Licking Creek watershed are shown on Figure 6.



PRINCIPAL MINE DRAINAGE SOURCES
LICKING CREEK WATERSHED

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION WHEELING FIELD STATION

FIGURE 6

FWPCA

WHEELING FIELD STATION

MINE DRAINAGE SOURCE INVESTIGATION

DEER CREEK WATERSHED SUMMARY

Drainage Area:	69 square miles
Location:	Clarion River Milepoint 21.3
Net Acid Load (at mouth) 1/ 2/	13,845 lbs./day
Number of Sources Investigated:	89
Number of Sources Discharging:	57
Total Source Acid Load Measured:	10,752 lbs./day
Major Acid Load Source Category:	Oil and gas wells, underground mines
Principal Sources:	Mine numbers 1043, 4253, 4337, 4516, 4531, 4532
Preliminary Abatement Cost Estimate, Principal Sources:	$24,000

Remarks: The only discharge encountered from an active operation was a 324 lbs./day acid loading from an active coal washery lagoon overflow.

The acid load of the six principal sources totals 6,773 lbs/day, about 75 percent of the total watershed source load measured. Pertinent data regarding the principal sources is given in the following table:

PRINCIPAL SOURCES

	Mine No.	Type	Receiving Stream	Flow (gpm)	pH	Specific Conductance	Acidity mg/l	Acidity lbs/da
1.	1043	Drift	Unnamed Trib.	16	2.6	6000	4360	837
2.	4253	Drift	Little Paint Creek	18	2.7	>8000	9235	1995
3.	4337	Gas Well	Judith Run	100	5.3	2400	740	888
4.	4516	Gas Well	Frills Run	120	5.4	1700	430	619
5.	4531	Gas Well	Unnamed Trib.	495	2.5	1275	290	1723
6.	4532	Gas Well	Unnamed Trib.	212	2.6	1200	280	711
							TOTAL	6773

1/ Acid Load Minus Alkaline Load.
2/ Average of Six Samplings, 1966.

Deer Creek discharged a net acid load to the Clarion River of 13,845 lbs./day during the 1966 survey. The mine drainage source investigation measured 10,752 lbs./day being discharged from 57 coal mines and abandoned oil and gas wells in the watershed. Four of the six principal sources listed are abandoned gas wells. The acid load from these four wells amounts to more than one-third of the total load measured from 57 coal mine and oil and gas well sources.

The stream survey measured some 3,000 lbs./day in Deer Creek that is not accounted for in the source inventory. This difference between the values is believed to be the result of abandoned oil and gas well discharges in the basin, similar to coal mine discharges in chemical character, which were not documented in the source investigation survey.

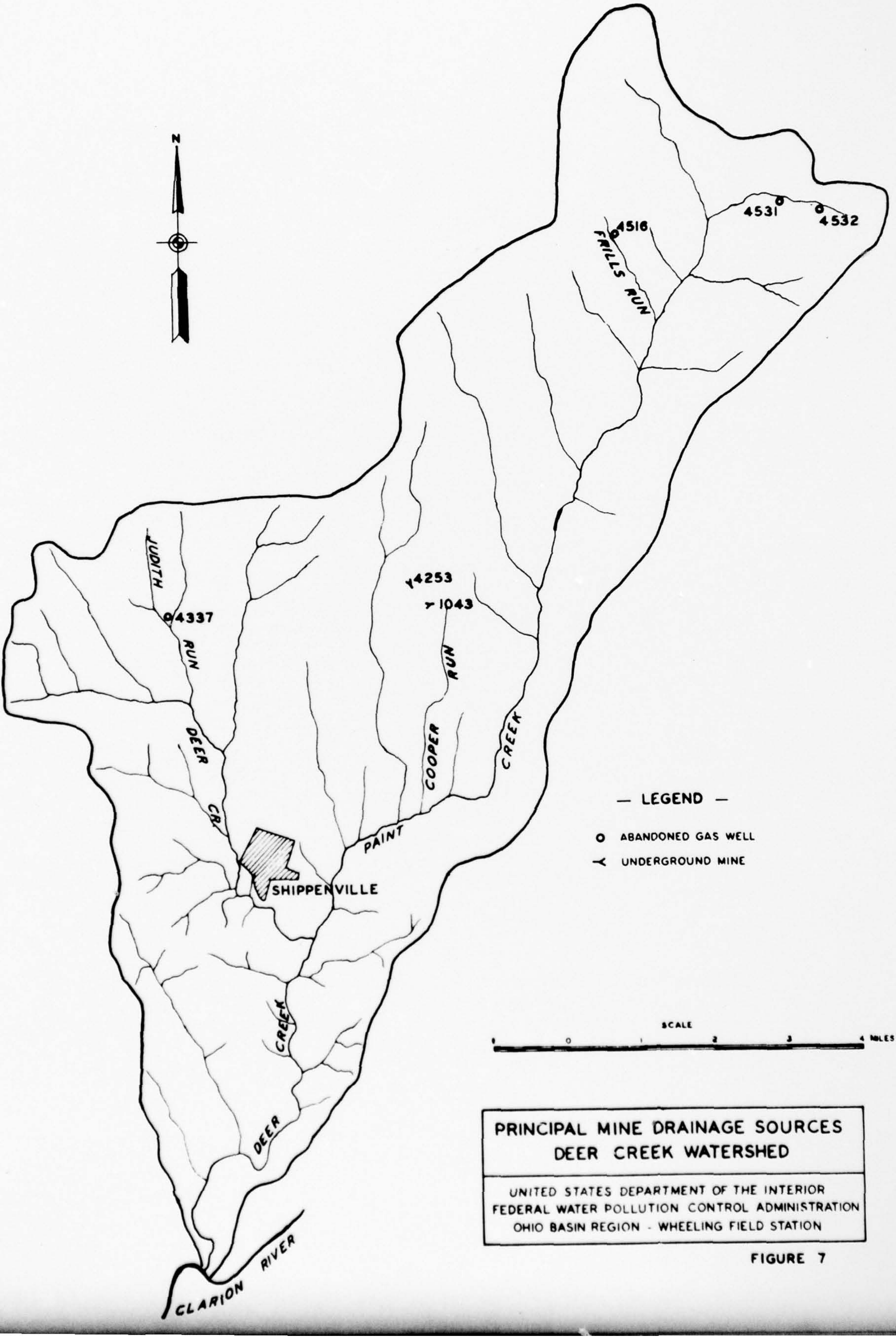
Because of the acid present in Deer Creek that is of an assumed origin, the absolute number of sources needed to be abated to eliminate the acid load discharged to the Clarion River is not available at this time. An additional field survey to locate and quantify the oil and gas well sources would be required to develop this data.

Assuming complete elimination of gas well discharges and 50 percent acid reductions from drift mine discharges, physical abatement of the six listed principal sources would reduce the acidity entering the Clarion River from this watershed about 40 percent. It is expected that plugging or other suitable physical measures employed at the abandoned oil and/or gas wells that are yet to be investigated will result in zero or near-zero acidity discharged to the Clarion River from this watershed.

A gross preliminary estimate of the cost of physical measures to control or reduce the pollutant effect of the six principal sources is $24,000. A

detailed engineering study is required to determine feasible construction measures and costs at each site.

The locations of the six principal sources in the Deer Creek watershed are shown on Figure 7.



PRINCIPAL MINE DRAINAGE SOURCES
DEER CREEK WATERSHED

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION - WHEELING FIELD STATION

FIGURE 7

ABATEMENT EFFECTS ON CLARION RIVER

The following table lists the average net acid loading values for the Clarion River at mouth and for its six principal acid-polluted tributaries. The values are averages of six samplings during summer, 1966:

STREAM LOCATION:	AVERAGE NET ACID LOAD (lbs./day)
Clarion River, at mouth.	126,712
Toby Creek (Clarion County) @ mouth.	47,582
Piney Creek @ mouth.	19,272
Licking Creek @ mouth.	16,850
Mill Creek @ mouth.	16,960
Deer Creek @ mouth.	13,845
Toby Creek (Jefferson County) @ mouth.	14,936

Using the principal sources listed for the six tributary watersheds (see individual watershed summaries), and the assumed acid reductions described for each watershed, the net acid load at the mouth of the Clarion River (table above) would be reduced to about 30,000 lbs./day. This level constitutes a 75 percent improvement over present conditions.

The principal sources listed for the Mill, Deer, and Licking Creek watersheds are the major acid contributors of the total number of sources identified in each watershed. Abatement of these principal sources would not effect alkaline conditions at the mouth of each drainage area. Assuming additional principal sources are identified in the Mill, Deer, and Licking Creek watershed, the contributions of these watersheds could be reduced to the point that the effect is essentially zero net acidity at the mouth of the Clarion River.

MINE DRAINAGE ABATEMENT COSTS

The preliminary cost estimates for abatement of the identified principal sources in the six tributary watersheds totals $2.45 million. This total has been rounded upward to $3.0 million to allow for abatement costs of presently unidentified abandoned oil and gas well sources.

THE OIL AND GAS WELL ACID POLLUTION PROBLEM

During the Clarion River mine drainage source investigation, abandoned oil and gas well discharges were sampled and measured when encountered in the coal mine areas. No specific attempt was made to locate such discharges during the mine drainage survey.

Thirty-five abandoned gas well discharges and one abandoned oil well discharge were documented in the field. A summary of pertinent data from the survey is tabulated below:

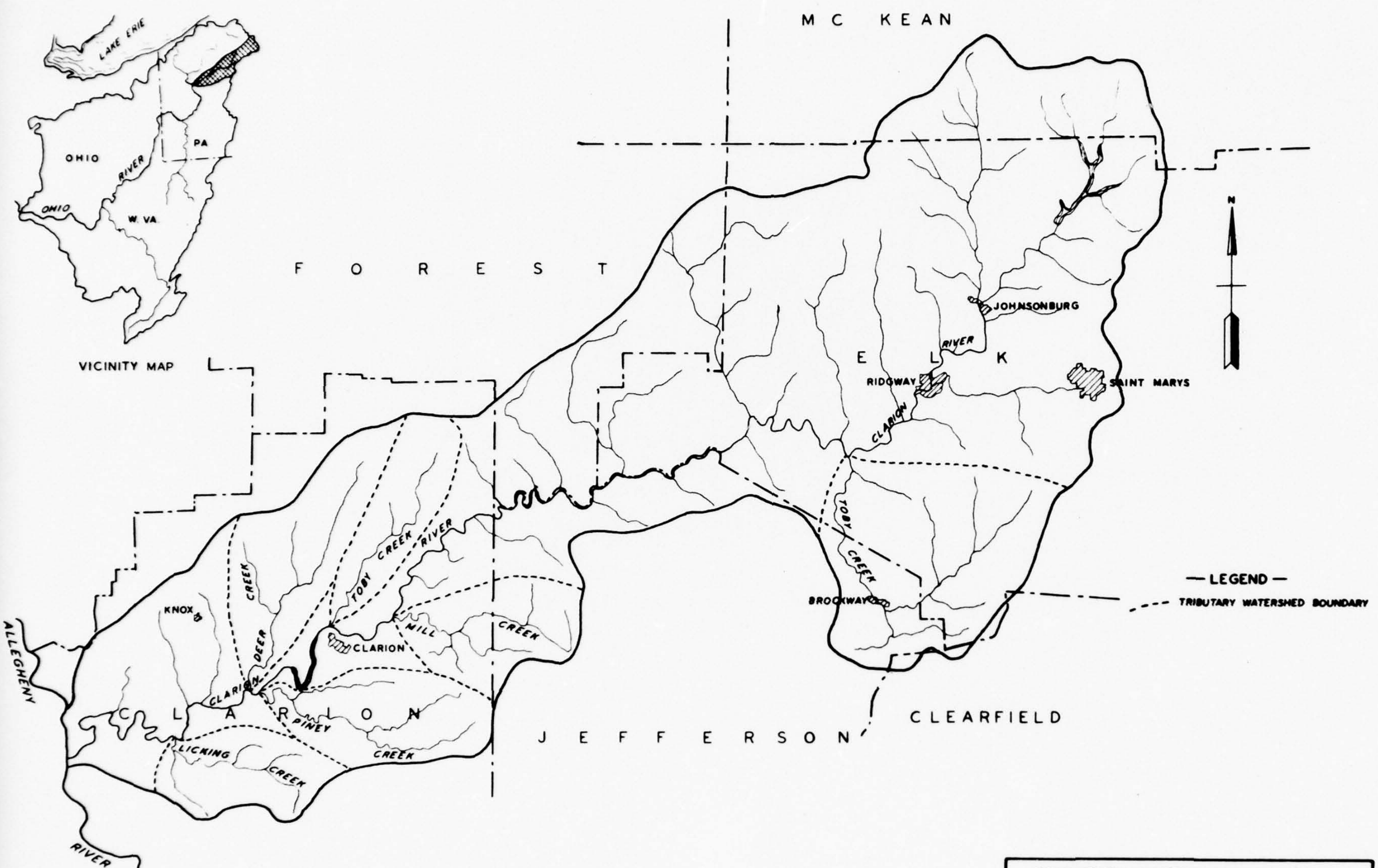
Watershed	Number of Wells	Flow range (gpm)	pH Range	Net acid load range (lbs./day)	Remarks
Toby Creek (Clarion County)	15	1-90	2.8-7.3	0-511	(23 of the 35 well discharges had pH values below 6.0)
Piney Creek	5	1-50	3.1-7.0	0-66	
Mill Creek	3	4-7	3.1-5.2	0-43	
Licking Creek	1	12	4.4	667	
Deer Creek	12	1-495	2.5-7.0	0-1722*	

*The second largest acid load source measured in the Deer Creek watershed, 1722 lbs./day.

Examination of a recent study made in this immediate area indicates the average density of abandoned oil and gas wells (mostly gas wells) in this area to be about 11 per square mile. (U.S. Bureau of Mines report to the Corps of Engineers, Pittsburgh District, concerning the proposed St. Petersburg reservoir.) Assuming this density to persist in the drainage areas of Mill, Licking, and Deer Creeks, nearly 2000 wells exist in the 177 square mile area. If only five percent of these have acid discharges, this would amount to about 100 sources in addition to coal mine sources.

The status of available data on these abandoned features is such that location and sampling in the field is the only way they can be documented.

Stream and coal mine discharge data comparisons in the Licking and Mill Creek watersheds suggest that abandoned gas well discharges are the principal sources of acid.



TRIBUTARY WATERSHEDS STUDIED
CLARION RIVER BASIN

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO BASIN REGION - WHEELING FIELD STATION

APPALACHIA PROGRAM

LOWER KNOX CREEK RESERVOIR PROJECT

Tug Fork Basin of the Big Sandy River Basin

by

U.S. Department of the Interior
Federal Water Pollution Control Administration
Ohio Basin Region
Cincinnati, Ohio
February 1969

APPALACHIA PROGRAM

LOWER KNOX CREEK RESERVOIR PROJECT

Tug Fork Basin of the Big Sandy River Basin

The water supply and water quality control needs as described in the March 15, 1965, and January 4, 1967, letters to Lt. Col. W. D. Falck, District Engineer, U.S. Army Engineer District, Huntington, West Virginia, state the Federal Water Pollution Control Administration evaluation of water supply and water quality control needs that might be met entirely or in part by the Lower Knox Creek Project. These letters are reproduced on the following pages.

c o p y

Ohio Basin Region
4676 Columbia Parkway
Cincinnati, Ohio 45226

January 4, 1967

Lt. Col. W. D. Falck
District Engineer
U. S. Army Engineer District, Huntington
Corps of Engineers
P. O. Box 2127
Huntington, West Virginia 25721

Dear Colonel Falck:

This letter summarizes the conclusions reached by FWPCA representatives attending the Appalachia study meetings on November 2 and 21, 1966, regarding a special report on Tug Fork, tributary of the Big Sandy River.

The February 1962 and April 1963 water supply and water quality control reports on the Big Sandy River Basin and a March 1965 letter that gave projections beyond those given in the report were reviewed. The objective was to determine if there was a need for water supply and quality control storage in the Tug Fork Basin in excess of that shown in the reports based on the findings of potential growth and expansion due to the Appalachia Program as determined by Spindletop.

It was determined that the water supply and water quality control needs as stated in the reports and letter are adequate for the projected future and will provide for economic expansion effected by the Appalachian Program as determined by Spindletop. Therefore, no benefits due to water supply and water quality control storage would accrue for additional reservoirs in the Tug Fork Basin at this time.

Sincerely yours,

/s/

Richard A. Vanderhoof
Acting Regional Director

c o p y

c o p y

700 East Jefferson Street
Charlottesville, Virginia 22901

Re: ORHED-PS

Col. Harrington W. Cockran
District Engineer
U. S. Army Engr Dist. Huntington
P. O. Box 2127
Huntington, West Virginia 25721

Dear Colonel Cockran:

Reference is made to your letter of March 2, 1965 concerning future needs for water quality control in the Big Sandy River Basin.

It is understood that every industrial site on the Big Sandy River, Louisa, Kentucky, to the Ohio River, has been optioned by some industry. Informal information available indicates that a 150 ton per day pulp and paper plant and five satellite plants to that industry are definitely interested in locating downstream from Louisa, Kentucky, and Fort Gay, West Virginia. Two chemical plants desire to locate on the navigable portion of the Big Sandy River. An aluminum plant has long had an interest in locating in the navigable portion of the Big Sandy River. Large electric generating facilities are now located on the Big Sandy River below Fort Gay, West Virginia. There is every indication that the lower Big Sandy River Basin will be heavily industrialized in the foreseeable future.

Satellite industries will probably develop in the area in areas of surplus labor. The Tug Fork of the Big Sandy is such an area. There is little present interest in the Tug Fork area. However, that area has a limited water supply, adequate for a light water using industry's water supply, but not adequate for water quality control. It is suggested that a part of the need indicated in the April 1963 report be developed in the Tug Fork Basin to the extent that the minimum assured flow be increased to 40 cfs. This water will be of definite use in the lower Big Sandy and of probable use in the Williamson, West Virginia, area. It is noted that there are no planned reservoir projects in the Tug Fork area and it is certainly reasonable to believe that some industrial use will eventually be made of the surplus labor in that area. The availability of an assured quantity of water should increase the probability of industrial development in the Tug Fork area.

With respect to your question concerning the probable need for storage for water qualtiy control beyond the year 1975, the following inforamtion is furnished for your use. The A. D. Little Study was formally furnished to this office in September 1964. As you know, that report discusses relatively large areas and sub-area J includes the Guyandot-Big Sandy-Little Sandy. It appears that the Big Sandy Basin is at least as favorable for future development as the Guyandot and the Little Sandy. Therefore, on the basis of percentage of increase of manufacturing employment, it can be expected that there will be about 28 percent increase in manufacturing employment from 1970 to 2010 in the Big Sandy River Basin. The same rate of growth for water quality control needs would require an additional 70 to 80 cfs of flow to receive and assimilate treated wastes from manufacturing processes.

An equally difficult forecast and computation concerns the needs for storage for water quality control in the Ohio River below the Big Sandy River Basin in the foreseeable future. Again, time has not permitted a detailed examination of the Ohio River main stem with the new high level locks and dams. It seems reasonable that with greater overall loads to the main stem, even with better treatment, that increased flow may be needed to assure a good quality of water in the main stem.

In summary, as you are pressed for a flow figure needed in the Big Sandy Basin to facilitate future planning, it would appear that your estimate of 100 to 150 cfs in addition to the 300 cfs additional needed by 1975 is a conservative figure for the year 2010.

It is requested that you use the figure with the knowledge that it is a very preliminary figure. It will be subject to change as the Comprehensive Study of the DHEW proceeds and new information is developed.

If we can be of any future assistance, we would be pleased to cooperate with you.

Sincerely yours,

Lloyd W. Gebhard
Regional Program Director
Water Supply and Pollution Control

c o p y

APPALACHIA PROGRAM
WATER SUPPLY AND WATER QUALITY CONTROL STUDY
CELINA RESERVOIR PROJECT
CUMBERLAND RIVER BASIN, KENTUCKY AND TENNESSEE

prepared for

U. S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS-APPALACHIA STUDY
U. S. ARMY ENGINEER DISTRICT
NASHVILLE, TENNESSEE

by

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO RIVER BASIN PROJECT
EVANSVILLE FIELD STATION, INDIANA

September 1967

Table of Contents

Request and Authority

In a letter dated March 21, 1967, the U. S. Department of the Army, Nashville Engineer District, Nashville, Tennessee, requested the Federal Water Pollution Control Administration, Ohio Basin Region, for information relative to water supply and water quality control needs in the area affected by the potential Celina Reservoir Project in the Appalachian Water Resources Survey.

This report was prepared under the authority of the Appalachian Regional Development Act of 1965, P.L. 89-4, Section 206C.

Purpose and Scope

The purpose of this investigation was to determine potential need and value of water supply and water quality control storage in the Celina Reservoir. Water supply needs in the immediate project area, which consists of Monroe and Cumberland Counties, Kentucky, and Clay County, Tennessee, are based on population and economic projections developed by the Department of Commerce, Office of Business Economics; and the Corps of Engineers, Office of Appalachian Studies, Cincinnati, Ohio. These projections reflect the developmental effect of the Appalachian Program on the study area. Water supply needs downstream of Celina, Tennessee are based upon data found in the Framework Study of the Ohio River Basin, Cumberland River Subbasin, by the Federal Water Pollution Control Administration, Cincinnati, Ohio.

The scope of the report is limited to the needs of the immediate project area and the main stem of the Cumberland River downstream of the proposed project to Eddyville, Kentucky.

Streamflow available for assimilation of waste loads is discussed in terms of natural flow.* Regulation of streamflow by reservoirs, such as those in the Cumberland River Basin, ordinarily improves low-flow stream characteristics. However, there may be occasions when this does not hold true. Therefore, natural flows are used since it is assumed that these flows should always be available and that flow regulation should by no means result in effects detrimental to potential or actual uses available before the regulating structures were placed in operation.

The potential reservoir would extend from Cumberland River mile 385.4 at the Kentucky-Tennessee state line to Wolf Creek Dam at mile 460.9. The total drainage area above the proposed damsite is 6308 square miles, 5789 of which are controlled by upstream reservoirs. The reservoir, as presently planned, has a total storage capacity of approximately 358,000 acre-feet at the maximum operating level. The major project purposes are power, recreation, and navigation.

* Natural flow is defined as that flow which was experienced and would be available without regulation.

Summary of Findings and Conclusions

There are no water supply or water quality control benefits that can be assigned to the potential Celina Reservoir Project.

By year 2020 Tompkinsville, Kentucky will have a projected water supply requirement of 1.4 mgd. Existing water supply facilities could be enlarged or new facilities added at a cost less than the cost of importing water from the proposed Celina Reservoir.

Burkesville, Celina, Gainesboro, Carthage, Hartsville, Gallatin, Ashland City, Clarksville-New Providence, Dover, Eddyville, and other communities taking water from the Cumberland River have projected 2020 water supply needs that can be met from the river based on the natural one day low flow with a thirty year recurrence interval.

The projected 2020 water supply needs of the Nasvhille metropolitan area can be met from the regulated flow of the Cumberland River.

The natural seven day low flow of the Cumberland River at Celina, Gainesboro, Carthage, Hartsville, Gallatin, Ashland City, Clarksville-New Providence, Dover, and Eddyville should be adequate to assimilate future waste loads from those communities and other communities whose waste loads eventually enter the Cumberland River.

The regulated seven day once in ten year low flow at Nashville would provide a greater assimilative capacity than the natural flow

at that location, but local water quality problems could occur in the future even with adequate waste treatment. The water quality problems and needs of the Nashville area are discussed in greater detail in the section on water quality control needs.

Streamflow Characteristics

Reservoirs already in operation and others under construction significantly modify the flow characteristics of the Cumberland River below Wolf Creek Dam, including the reach in which Celina Reservoir would be located. The following tabulation shows natural low flow characteristics and regulated flows on the Cumberland River as determined by the Corps of Engineers. Reservoirs now in the planning stage would not significantly affect the regulated flows.

	NATURAL FLOW		REGULATED FLOW	
LOCATION	7 da. once in 10 yrs	1 da. once in 30 yrs	7 da. once in 10 yrs	1 da. once in 30 yrs
Rowena, Ky. (Wolf Cr.)	96	51	330	36
Celina, Tenn.	190	112	840	205
Carthage, Tenn.	520	330	3200	1900
Below Old Hickory Dam	480	260	3600	2300
Nashville, Tenn.	560	330	3800	2400
Clarksville, Tenn.	640	370	4200	2700
Dover, Tenn.	710	430	4200	2700
Smithland, Ky.	800	520	4700	3400

The flows available in the Cumberland River provide almost unlimited quantities of water for municipal and industrial use and dilution of sewage treatment plant effluents with the exception of the Nashville metropolitan area. In following sections of this report, selected centers of population are used to illustrate the relationship between available flow in the Cumberland River and the projected needs for water supply and pollution control. Emphasis is placed on the water quality control needs of the Nashville metropolitan area.

Present Water Use, Sources of Supply and Treatment Facilities

There are no population centers using large amounts of water within the immediate project area. The town of Burkesville, Kentucky, 1960 population 1688, obtains its water supply from the Cumberland River. The present water facilities serve a population of 1750 with an average use of 0.10 mgd or a per capita use of 57 gpd.

The town of Tompkinsville, Kentucky, 1960 population 2091, has water supply facilities that serve a population of 3000 from a small impoundment on Mill Creek. Average daily water use is 0.30 mgd and per capita use is 100 gpd.

Water purification plants are operated by Burkesville and Tompkinsville.

Downstream of the proposed reservoir, the major centers of population are Gallatin, Nashville metropolitan area, and Clarksville, Tennessee, all of which obtain their water supplies from the

Cumberland River. Minor centers of population are Celina, which obtains its supply from the Obey River; Gainesboro, Dover, Carthage, Eddyville, and Ashland City, which obtain supplies from the Cumberland River; and Hartsville, which has auxiliary wells in addition to its source of supply from the Cumberland River. Present water use and type of treatment for selected areas downstream of the proposed reservoir are shown in the following tabulation:

Municipality	Pop. Served	Use, mgd	Per Capita Use, gpcd	Type Treatment
Celina	1,300	0.075	56	Purification*
Gainesboro	2,000	0.10	50	Purification *
Carthage	3,000	0.25	83	Purification*
Hartsville	1,600	0.15	94	Purification*
Gallatin	13,125	1.0	76	Purification*
Nashville metropolitan area	315,000	37.8	120	Purification*
Ashland City	1,740	0.09	52	Purification*
Clarksville-New Providence	35,000	2.5	71	Purification*
Dover	1,000	0.07	70	Purification*
Eddyville	400	0.02**	50	Purification*

Ground water is not a major source of supply in the study area, nor is it available in sufficient quantity to meet large projected needs.

* Consists of mixing, flocculation, sedimentation, filtration, chlorination.

** Estimated

Present Water Quality and Waste Treatment Facilities

Available data indicate that the Cumberland River is generally of good mineral and bacteriological quality as shown in the tabulation on the following page.

Ground water in the Cumberland River Basin generally meets the standards suggested by the U. S. Public Health Service for the chemical quality of drinking water except that the iron content is frequently in excess of 0.3 mg/l and often exceeds 3 mg/l. Therefore, removal of iron is desirable for most uses of water.

The following tabulation lists municipalities considered in this report that have or are planning to construct waste treatment facilities and the type of treatment currently provided:

Municipality	Treatment
Burkesville	Secondary
Tompkinsville	Primary 1/
Celina	None 1/
Gainesboro	Secondary
Carthage	Primary
Hartsville	Secondary
Gallatin	Secondary
Nashville	Secondary 2/
Ashland City	Secondary
Clarksville	Secondary
New Providence	Secondary
Dover	Septic tanks 1/
Eddyville	Secondary

1/ Secondary treatment plant is under construction.

2/ Present secondary treatment plant is inadequate but construction is now in progress for additional facilities which will increase the capacity of the plant and provide adequate treatment. Plans ultimately call for serving all of Davidson County, Tennessee by Nashville metropolitan area sewage treatment plants.

SURFACE WATER QUALITY OF CUMBERLAND RIVER

Item	At Burkesville				At Mouth Obey River			At Carthage			At Nashville Water Works Intake			Near Dover		
	Max.	Avg.	Min.		Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.
a/		b/		c/		d/			e/			f/			f/	
Ph	7.7	7.1	6.3	6.5	7.7	7.4	7.3	7.5	7.4	7.2	10.5	8.3	7.6	7.9	7.6	7.3
Spec. Cond.	165	124	101	140	174	152	128	175	157	142	213	133	109	283	214	183
Fe	0.2	0.0	0.0	--	4.0	1.0	0.0	1.6	0.6	0.0	3.3	0.6	0.0	2.0	1.1	0.1
SO_4	24	17	12	22	28	17	7	26	14	7	21	14	12	16	13	7
Cl.	5	2	1	1.5	30	10	3	11	7	3	9	5	4	34	12	3
Fl.	0.2	0.1	0.0	--	0.7	0.2	0	0.7	0.2	0.0	0.2	0.1	0.0	0.7	0.2	0.0
Dis. Solids	104	77	62	--	100	69	22	122	94	44	123	86	57	217	128	50
Total Hard.	66	50	41	48	94	65	44	86	73	51	126	81	60	170	99	56
Alk.	--	--	--	38	76	55	31	74	60	44	91	58	44	108	87	49
NO_3 as NO_3	1.5	1.1	0.3	--	1.5	0.5	0.0	1.2	0.6	0.2	1.1	0.3	0.0	3.2	1.1	0.1
PO_4 as PO_4	--	--	--	--	0.6	0.3	0.0	0.7	0.3	0.0	0.8	0.2	0.0	1.2	0.3	0.0
												d/				
Temp. °C				14	18	9	6	18	12	7	20	9	7	27	12	6
BOD_5 @ 20°C				2.7	1.2	0.7	0.5	1.1	1.0	0.8	2.4	1.7	1.1	2.6	1.6	1.0
D.O.				6.8	12.0	10.5	9.3	11.1	10.2	8.9	10.9	9.4	6.0	11.0	9.9	6.0
Coliform, MPN per 100 ml in 1000's					15.0	0.0	0	24.0	3.7	.9	24.0	0.6	.09	460.0	2.0	.9

a/ All values in mg/l except specific conductance in micromhos, pH in pH units, and other parameters as noted.
b/ Data obtained from 95 samples collected Jan. 1952-Sept. 1954 and contained in Quality of Surface Waters of Kentucky 1951-1953 and 1953-1955, published jointly by the Agricultural and Industrial Development Board of Kentucky and the U. S. Geological Survey.
c/ Single sample collected Oct. 8, 1966 and analyzed by personnel of the Evansville, Indiana Field Station of the Federal Water Pollution Control Administration.
d/ Seven samples collected Jan. 1958-Sept. 1960.
e/ Six samples collected Dec. 1958-Sept. 1960.
f/ Twelve samples collected Jan. 1963 - Dec. 1963.
* Median values are shown for coliforms instead of average values.

Data on samples in d, e, and f, are contained in Water Quality of Tennessee Surface Streams, 1960 and 1963, published by the Tennessee Stream Pollution Control Board. Samples were collected and analyzed by the staff of the Tennessee Stream Pollution Control Board.

Economy

Population and employment projections for the Celina Reservoir area were developed from benchmark projections by the Office of Appalachian Studies, Corps of Engineers. Population trends are shown below.

	Population			
	1960	1980	2000	2020
Cumberland County, Kentucky	7835	7200	9980	13900
Burkesville	1688	2100	2650	3900
Monroe County, Kentucky	11799	10910	14660	19800
Tompkinsville	2091	2300	4400	5000

Disaggregation of employment data by Standard Industrial Classification Code and adjustment of the data for future conditions results in the following trends for industries using large amounts of water.

Area/Industry	SIC No.	Employees 1980	2000	2020
Burkesville				
Food & Kindred Products	20	10	11	28
Chemical & Allied Products	28	--	5	15
Tompkinsville				
Food & Kindred Products	20	105	111	283
Chemicals & Allied Products	28	10	25	55

Water Supply Needs

Burkesville, Tompkinsville, and Celina are in the economic impact area of the potential project, and the water supply needs for those communities were developed from benchmark projections by the Office of Appalachian Studies.

The remaining communities are outside the impact area and their water supply needs were based on data in the framework study of the Ohio River Basin prepared by the Federal Water Pollution Control Administration.

Most of the projected water supply needs are expected to be met from surface supplies. Total future municipal and industrial water supply needs for communities considered in this report are tabulated below:

Municipality	Total M & I Water Supply Needs, mgd 1980	2000	2020
Burkesville	0.20	0.30	0.56
Tompkinsville	0.53	1.00	1.42
Celina	0.13	0.39	1.02
Gainesboro	0.31	0.81	2.95
Carthage	0.51	1.09	2.34
Hartsville	0.38	0.67	1.33
Gallatin	2.00	4.47	9.87
Nashville metropolitan area	121	200	352
Ashland City	0.33	0.73	1.62
Clarksville-New Providence	3.94	7.21	12.0
Dover	0.16	0.33	0.67
Eddyville	0.35	0.57	1.02

Water Quality Control Needs

The following tabulation shows estimated wastewater return flows in year 2020 for the principal communities considered in this study

together with the natural and regulated flows at selected points along the Cumberland River.

Municipality	Return flow, cfs 2020	Flow, cfs 7 day, 1 in 10 year Nat.	Reg.
Celina	1.4	190	840
Gainesboro	4.1	>190	> 840
Carthage	3.3	520	3200
Hartsville	1.9	>520	>3200
Gallatin	13.7	>520	>3200
Nashville Metropolitan area	491	560	3800
Ashland City	2.3	>560	>3800
Clarksville-New Providence	16.7	640	4200
Dover	0.9	710	4200
Eddyville	1.4	>710	>4200

Natural flows along the main stem of the Cumberland River are sufficient to provide needed assimilative capacity for the projected wastewater discharges in the study area with the exception of the Nashville metropolitan area, provided that adequate waste treatment and control measures are placed in effect. In the Nashville area, where projected pollution loads are considerably larger than the other communities in the study area, the assimilative problem is complicated by several factors; namely, the discharge of wastewaters into the pool

formed by Cheatham Dam and the possible effect of highly variable streamflows resulting from hydroelectric peaking operation at upstream reservoirs.

The impoundment formed by Cheatham Dam below Nashville has resulted in the formation of a relatively deep pool with considerable reduction in the velocity of flow. It is reasonable to conclude that this modification of stream characteristics has resulted in a reduction in the assimilative capacity of the stream due to the decrease in oxygen transfer because of reduced turbulence and velocity, and due to the increase in depth through which oxygen transfer must take place. In addition there is a problem of less uniform mixing of the wastewaters with the streamflow. The assimilative mechanics of the Cumberland River in the Nashville area were studied by the Tennessee Department of Public Health in 1938 and 1939 prior to the construction of Cheatham Dam; however, there have not been sufficient field studies since that time to make reliable estimates of the assimilative capacity of the river under present low flow conditions.

Fluctuating streamflow, resulting from regulation of the present reservoir system for hydropower production also have undetermined effects on the assimilative capacity of the Cumberland River. The daily flow from Old Hickory Reservoir fluctuates between zero and 30,000 cubic feet per second, but releases would be zero for only a few hours of the day. The minimum average daily flow that has occurred during the past several years is 2040 cubic feet per second. For navigation purposes, there is a minimum tailwater elevation that must be maintained at Old Hickory, and

during off-peak periods, it is sometimes necessary to operate one unit in order to maintain the elevation.

Inadequate mixing of treated wastes during periods of low flow when stream velocities are low could result in local water quality problems depending upon the length of the low flow period. During peaking periods, the situation would probably be somewhat improved because stream flow velocities are higher.

At present, fish flesh tainting is experienced in the Cheatham Dam pool below Nashville. The most probable cause of this problem is the wastes from the Nashville metropolitan area. No identification of the specific cause of the problem has yet been made, nor has the areal extent of the problem been defined. However, it is possible that the effects of this pollution would be less severe if low flows in the Cumberland River at Nashville were more uniformly regulated.

In view of the foregoing, it is concluded that future problems might occur in the Nashville area with dissolved oxygen reductions below acceptable levels due to limited assimilative capacity for the projected waste loads following adequate secondary treatment; however, water quality control storage for flow regulation cannot be justified at this time. The scope of the study does not permit an accurate determination of the assimilative mechanics involved. This can be accomplished only following detailed field study of the stream stretch in question.

If oxygen depletion should become a problem in the Nashville area, there are several measures that might be utilized to maintain acceptable

water quality standards. Among these are the following:

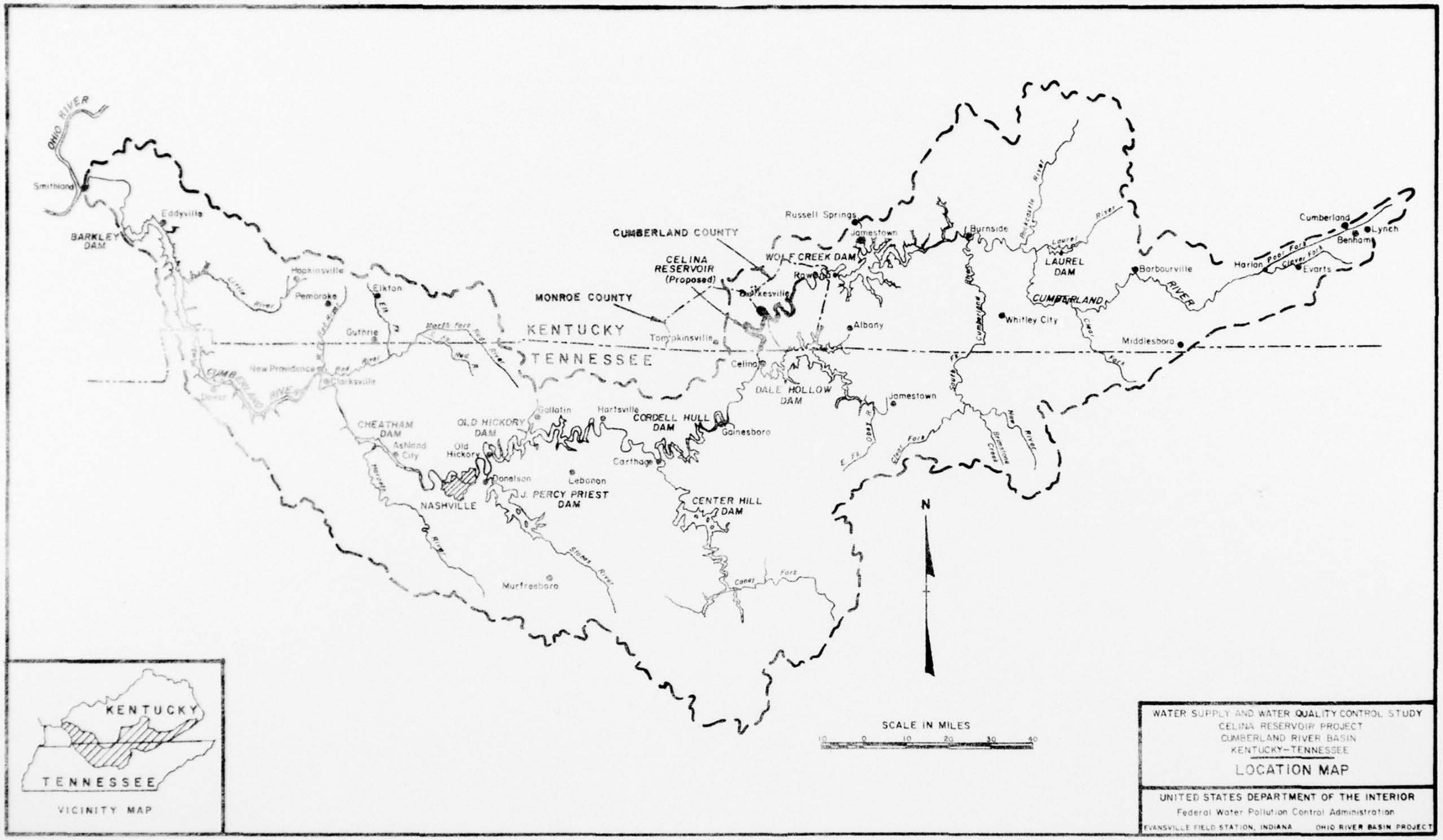
1. Reallocation of storage in upstream reservoirs to further augment low flows in the Nashville area.
2. Utilization of additional treatment measures beyond conventional secondary treatment.
3. Development of improved means for mixing treated wastewaters with the stream flow.
4. In-stream reaeration at critical points.

In addition, the maintenance of suitable water quality below Celina Reservoir will require the following water pollution control measures:

1. Removal of at least 85 percent of waste loads entering the stream as measured by the ultimate first stage biochemical oxygen demand. Removal of 90 percent or greater may be necessary for the Nashville metropolitan area some time in the future.
2. Removal of all settleable solids that will form putrescent or otherwise objectionable sludge deposits.
3. Removal of oil, scum, floating materials, and substances producing taste and odor to a degree required to prevent unsightly or deleterious conditions either in the water or the aquatic life therein.
4. Removal of all substances that are toxic or harmful to human, animal, plant, or aquatic life either by themselves or in combination with other substances.

5. Cooling of heated discharges to a temperature that will not impair use of the receiving stream.
6. Reduction of harmful bacteria to a level that will not impair use of the waters.

The quality of water to be expected in the proposed Celina Reservoir as indicated by the tabulation for Burkesville on page six, should not in any way impair recreation activities. Future waste loads, when properly treated before discharge to the reservoir, should not prove detrimental to the overall quality of the water in the reservoir.



OHIO RIVER
Smithland
BARKLEY DAM
Eddyville
Hopkinsville
Pembroke
Elkton
Guthrie
New Providence
Clarksville
CUMBERLAND RIVER
KENTUCKY
TENNESSEE
MONROE COUNTY
CUMBERLAND COUNTY
CELINA RESERVOIR (Proposed)
WOLF CREEK DAM
Russell Springs
Jamestown
Tompkinsville
Celina
Albany
DALE HOLLOW DAM
Jamestown
CHEATHAM DAM
Ashland City
OLD HICKORY DAM
Old Hickory
Gallatin
Hartsville
CORDELL HULL DAM
Gainesboro
Carthage
Lebanon
Donelson
NASHVILLE
J. PERCY PRIEST DAM
CENTER HILL DAM
Murfreesboro
Stones River
Caney Fork
Burnside
LAUREL DAM
Laurel River
CUMBERLAND RIVER
Whitley City
Barbourville
Middlesboro
Harlan
Poor Fork
Clover Fork
Evarts
Cumberland
Benham
Lynch
N
SCALE IN MILES
10 0 10 20 30 40
KENTUCKY
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APPALACHIA PROGRAM
WATER SUPPLY AND WATER QUALITY CONTROL STUDY
DEVILS JUMPS RESERVOIR PROJECT
CUMBERLAND RIVER BASIN, KENTUCKY AND TENNESSEE

prepared for

U. S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS - APPALACHIA STUDY
U. S. ARMY ENGINEER DISTRICT
NASHVILLE, TENNESSEE

by

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
OHIO RIVER BASIN PROJECT
EVANSVILLE FIELD STATION, INDIANA

October 1967

Table of Contents

Request and Authority

In a letter dated March 21, 1967, the Department of the Army, Nashville Engineer District, Nashville, Tennessee, requested the Federal Water Pollution Control Administration, Ohio Basin Region, for information relative to water supply and water quality control needs for the area affected by the proposed Devils Jumps Reservoir Project of the Appalachian Water Resources Survey.

This report was prepared under the authority of the Appalachian Regional Development Act of 1965, P.L. 89-4, Section 206C.

Purpose and Scope

The purpose of this investigation was to determine potential need and value of water supply and water quality control storage in the proposed Devils Jumps Reservoir, Cumberland River Basin, Kentucky and Tennessee. Water supply needs are based on population and economic projections developed by the Department of Commerce, Office of Business Economics; and the Corps of Engineers, Office of Appalachian Studies, Cincinnati, Ohio. These projections reflect the developmental effect of the Appalachian Program on the study area.

The study area for this report consists of McCreary County, Kentucky and Fentress and Scott Counties, Tennessee. Report emphasis is on future water supply and water quality control needs for the Whitley City, Jamestown, and Oneida water service areas.

The potential Devils Jumps Dam would be in Kentucky on the South Fork of the Cumberland River at mile 48.1, and the reservoir would extend upstream into Tennessee. The drainage area above the dam site is 957 square miles. As presently planned, the reservoir would have a storage capacity of 4,136,000 acre-feet below the top of the flood control pool. The major project purposes are flood control, power, and recreation.

Summary of Findings and Conclusions

Based on existing information, there are no water supply or water quality control benefits that can be assigned to the Devils Jumps Reservoir Project.

Water supply needs to year 2020 for the Whitley City, Oneida, and Jamestown water service areas can be supplied by ground water or a combination of ground water and small impoundments at annual costs less than the annual costs of transmission facilities from Devils Jumps Reservoir to the areas under consideration.

The projected needs to year 2020 for water quality control downstream of the proposed reservoir can be satisfied by the estimated reservoir seepage loss of 45 cfs which was obtained from the Corps of Engineers.

Should unforeseen municipal and industrial developments occur, it may become necessary at some future date to consider reallocation of reservoir storage to provide for water quality control and water supply.

Present Water Use, Sources of Supply, and Treatment Facilities

Whitley City has no water supply system but receives its supply from the town of Stearns which has a purification plant and two small lakes which serve as a source of supply. Per capita water use is not known but is estimated to be approximately 50-70 gallons per day.

Oneida, Tennessee utilizes ground water as its source of water supply. The town has a water purification plant serving a population of 2150. Iron removal is included as part of the purification process. Per capita water use at the 1960 level was 93 gallons per day.

Jamestown, Tennessee obtains its water supply from a small lake. The town's water purification plant served a population of 1400 in 1960. Estimated municipal water use at the 1960 level was 90 gallons per capita day.

Whitley City and Oneida are underlain by the Pottsville Formation of Pennsylvanian age.. It is composed principally of shale and sandstone interspersed with thin beds of coal, siltstone, and limestone. Wells adequate for municipal and industrial supplies are normally deeper than 150 feet and depths of 300 feet are not uncommon. Yields of 20-100 gpm can be obtained. Depths to water range from 10-100 feet.

Jamestown, in the Eastern Highland Rim physiographic region, is underlain by limestones of Mississippian age. Well yields of 20-100 gpm can be obtained from depths of 60-100 feet. An occasional dry well may be encountered.

Present Water Quality and Waste Treatment Facilities

Available water quality data in the study area is limited. The South Fork of the Cumberland River was sampled at mile 70.1, twenty-two miles above the proposed dam site, by the Tennessee Stream Pollution Control Board in 1958, 1959, and 1960. Pertinent data for these samples are shown in the following tabulation:

Parameter [a]	1/29/58	12/2/58	1/21/59	2/3/59	3/24/59	6/14/60	9/13/60
pH	7.3	7.3	6.6	7.0	7.3	7.0	7.0
Dissolved oxygen	11.8	11.7	12.0	12.0	10.8	8.0	7.8
Temp. °C	4	4	3	4	8	24	22
BOD_5 @ 20 °C	1.0	1.4	0.3	0.8	0.6	0.8	0.6
Coliform MPN per 100 ml in 1000's	0.1	7.5	4.6	0.1	0.0	---	2.2
SO_4	10	17	19	17	20	20	46
Cl	18	7	14	7	4	2	4
Fl	0.0	0.7	0.1	0.2	0.0	0.0	0.0
NO_3 as NO_3	0.1	0.5	0.8	0.4	0.2	0.3	0.4
PO_4 as PO_4	0.4	0.0	0.0	0.0	0.5	0.0	0.1
Total hardness	60	62	17	27	22	36	60
Alkalinity	29	35	37	12	8	8	16
Est. avg. daily flow, cfs	1800	440	6500	500	1500	100	800

a/ All values in mg/l except pH in pH units and other parameters as noted.

Above mile 70.1 and in the New River area of the drainage basin, considerable mining has occurred in the past, and many small streams are acidic throughout the year. Analyses of samples collected by the Federal Water Pollution Control Administration at New River, Tennessee (D.A. = 382 mi^2) indicate that combined acid loadings from small tributaries upstream cause iron concentrations in excess of 1.0 ppm and acidic conditions in the stream. Data for this station is shown below:

Parameter [a]	3/30/66	5/22/66	6/18/66	7/15/66	8/26/66	10/8/66
pH	7.0	5.9	6.8	6.8	5.8	6.5
Dissolved Oxygen	---	8.8	6.8	6.8	8.4	9.0
Temp. °C	11	21	25	29	20	15
Spec. Cond.	230	220	300	260	190	330
BOD_5 @ 20 °C	---	---	---	---	---	3.5
SO_4	---	44	140	50	72	96
Fe	0.2	1.0	0.9	1.1	2.5	1.0
Flow in cfs	164	206	121	28	540	62

The limited data available do not permit more than a generalization as to the effect on the proposed reservoir of the stream quality conditions indicated. However, it is believed that the mineral quality of the water in the reservoir below mile 70.1 would be satisfactory for recreation activities. In the New River area, the high iron

a/ All values in mg/l except pH in pH units and other parameters as noted.

concentrations and acidic conditions could have a moderating effect on recreation activities in small embayments of the reservoir. At present there is no reason to suspect that bacteriological quality would not be satisfactory for recreation activities.

It is reported by the U. S. Geological Survey that ground-water from the Pottsville Formation generally meets the standards suggested by the U. S. Public Health Service for the chemical quality of drinking water except that the iron content exceeds 0.3 mg/l and frequently exceeds 3 mg/l; therefore, removal of iron is desirable for most uses of the water. The water normally has less than 120 mg/l of hardness, less than 60 mg/l of sulfate, and less than 20 mg/l of chloride. Despite the coal beds contained in the Pottsville Formation, and the many abandoned coal mines from which acidic water drains into the streams, ground water analyses have not shown pH's to be excessively low.

A few chemical analyses of water from springs and wells in the carbonate rocks of the eastern Highland Rim indicate that the water ranges in hardness from 50 to 200 mg/l, has negligible amounts of sulfate and chloride, and has less than 400 mg/l of dissolved solids. The water is likely to have more than 0.3 mg/l and occasionally as much as 5 mg/l of iron.

Existing waste treatment facilities in the study area are shown below:

Municipality	Treatment	Discharge to
Oneida	Secondary	Pine Creek to S. Fork Cumberland R.
Jamestown	Primary	Rockcastle Cr. to Buffalo Cr. to E. Fork Obey River

A consulting engineer is presently preparing plans for a secondary sewage treatment plant to serve Jamestown. The Kentucky Water Pollution Control Commission has no information to indicate that a sewage treatment plant will be constructed at Whitley City in the near future.

Streamflow Characteristics

For water supply purposes the dependable streamflow is considered to be the minimum daily flow having a recurrence interval of 30 years. This flow is estimated to be 9.8 cfs in the South Fork of the Cumberland River near Stearns, Kentucky.

For water quality control purposes, the dependable streamflow is considered to be the seven day average low flow having a recurrence interval of 10 years. This flow is estimated to be 16.7 cfs near Stearns.

It is estimated by the Corps of Engineers that the seepage loss from the proposed Devils Jumps Reservoir would be 45 cubic feet per second.

Economy

The principal communities in the study area are Whitley City, Kentucky and Oneida and Jamestown, Tennessee.

Population and employment projections for the study area were developed from benchmark projections by the Office of Appalachian Studies, Corps of Engineers. Population trends are shown on the following page.

	1960	1980	2000	2020
McCreary County, Ky	12,463	15,660	21,910	30,810
Whitley City Water Service Area (incl. Stearns)	1,100	3,300	9,550	18,400
Scott County, Tenn.	15,413	15,000	20,500	28,600
Oneida Water Service Area	2,150	6,150	13,900	24,900
Fentress County, Tenn.	13,288	16,710	23,380	32,860
Jamestown Water Service Area	1,400	4,800	11,500	21,000
Study Area Total	41,164	47,370	65,790	92,270

For industries using large amounts of water, estimated future employment trends by Standard Industrial Classification Code are shown below.

Location/Industry	SIC NO.	Employees 1980	2000	2020
Whitley City Water Service Area				
Food & Kindred Products	20	51	77	149
Chemicals & Allied Products	28	30	71	126
Subtotal		81	148	275
Oneida Water Service Area				
Food & Kindred Products	20	95	111	202
Chemicals & Allied Products	28	56	103	171
Subtotal		151	214	373
Jamestown Water Service Area				
Food & Kindred Products	20	74	92	169
Textile Mill Products	22	16	20	20
Chemicals & Allied Products	28	44	86	143
Subtotal		134	198	332
Total Employment for SIC Nos. 20,22, & 28		366	560	980
Total Employment for Study Area		12510	18380	25500

Water Supply Needs

Rising population and rising standards of living will result in increased per capita use of water in the future and municipal water supply needs have been projected on that basis. Per capita uses of 105, 115, and 130 gallons per day have been projected for years 1980, 2000, and 2020, respectively.

Increased industrial recirculation of water in the future will tend to reduce fresh water intake requirements per employee though total fresh water intake will continue to increase. Industrial water supply requirements for the study area are based on present use modified for the future, by projected recirculation ratios that are within the limits presently being attained in various industries in other geographical areas.

Projected municipal and industrial water supply requirements and additional needs are shown in the tabulation below:

Municipality		Water Requirements, mgd 1980	2000	2020
Whitley City Water Service Area				
Municipal		0.35	1.10	2.39
Industrial		.49	.81	.93
	Total	.84	1.91	3.32
Estimated safe yield of present source		0.10	0.10	0.10
Additional need		0.74	1.81	3.22

Municipality	Water Requirements, mgd 1980	2000	2020
Oneida Water Service Area			
Municipal	0.65	1.60	3.23
Industrial	.91	1.17	1.28
Total	1.56	2.77	4.51
Estimated safe yield of present source	0.40	0.40	0.40
Additional need	1.16	2.37	4.11
Jamestown Water Service Area			
Municipal	0.50	1.32	2.73
Industrial	.72	.97	1.07
Total	1.22	2.29	3.80
Estimated safe yield of present source	0.30	0.30	0.30
Additional need	0.92	1.99	3.50

Cost studies indicate that the additional 2020 water supply needs of the Whitley City, Jamestown, and Oneida water service areas can be supplied by ground water or a combination of ground water and small impoundments at less cost than supplying the additional needs from the proposed Devils Jumps Reservoir. Some of the main advantages of ground water for municipal water supply are: (1) the ability to obtain adequate supplies close to the point of distribution; (2) the lower capital outlay required to provide a supply; (3) the usually less

expensive cost of treatment required to provide waters suitable for municipal use; (4) the ability to expand the system by small increments as water demands increase.

Water Quality Control Needs

Studies by the U. S. Public Health Service in the Cincinnati, Ohio area showed that for a well-rounded warm water fish population, dissolved oxygen concentrations should not be below 5 mg/l for more than 8 hours of any 24 hour period, and at no time should it drop below 3 mg/l. For the purposes of this report, a minimum dissolved oxygen content of 5 mg/l is used. This will preserve desirable aquatic life and enhance recreational use.

In addition, in order to maintain satisfactory water quality in the reservoir and also downstream of the dam in future years, the following would be required:

1. Removal of at least 85 percent of waste loads entering the stream and/or reservoir as measured by the ultimate first stage biochemical oxygen demand.
2. Removal of all settleable solids that will form putrescent or otherwise objectionable sludge deposits.
3. Removal of oil, scum, floating materials, and substances producing taste and odor to a degree required to prevent unsightly or deleterious conditions.

4. Removal of all substances that are toxic or harmful to human, animal, plant, or aquatic life either by themselves or in combination with other substances.
5. Cooling of heated discharges to a temperature that will not impair use of the receiving stream.
6. Reduction of harmful bacteria to a level that will not impair use of the waters.
7. Abatement and control of acid mine drainage in the basin.

At normal reservoir operating levels there would be several miles of open stream between Devils Jumps tailwater and Lake Cumberland headwater. For quality control calculations, it has been assumed that effluent from a future sewage treatment plant in the Whitley City area would enter the South Fork of the Cumberland River in the reach of open stream.

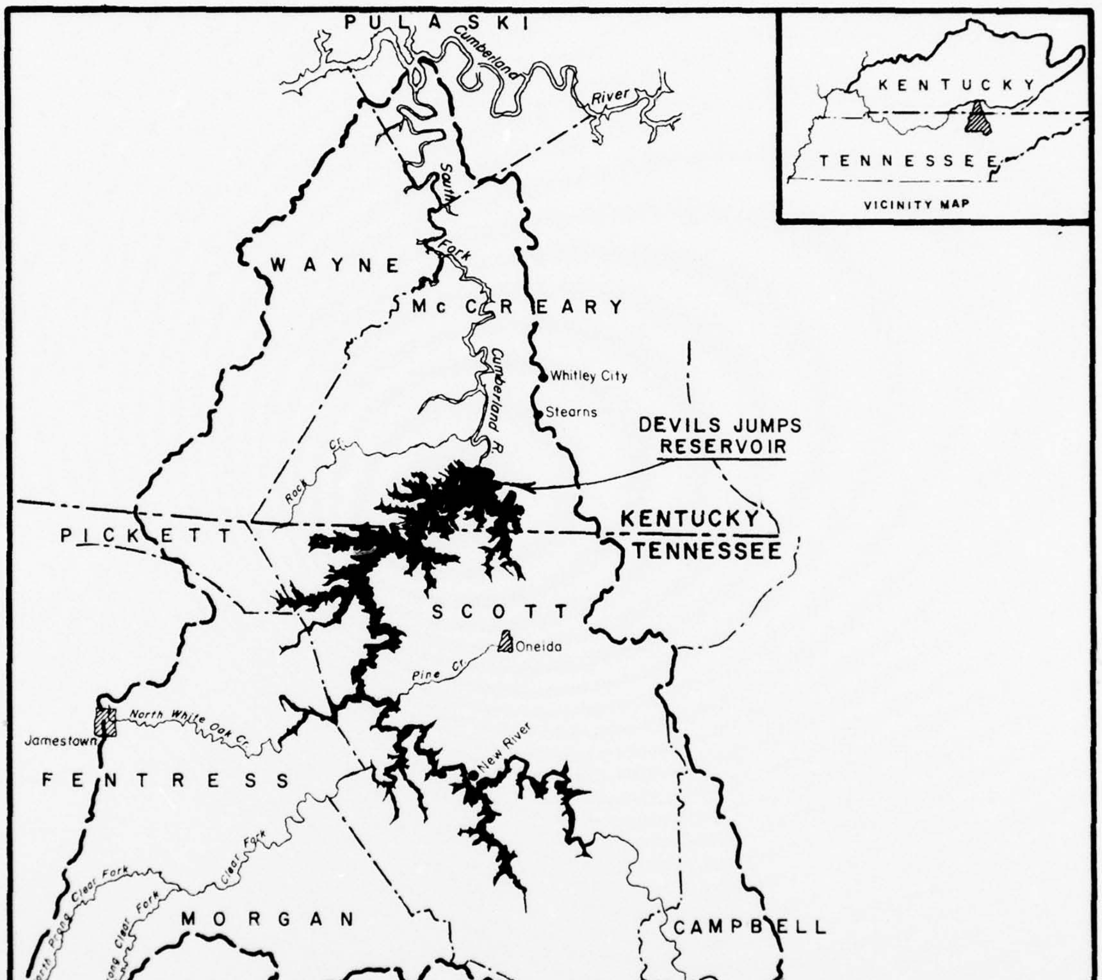
Quality control flows have been computed on the premise that all wastes will receive at least secondary treatment. On this basis, it was found that streamflow of 15 cfs would be required for quality control below Devils Jumps reservoir in the summer months by 1980 and that the requirement would be 36 cfs by year 2020. The estimated reservoir seepage loss of 45 cfs would satisfy water quality control requirements. It is realized that reservoir seepage loss might be low in dissolved oxygen content but it would only be during off-peak power periods such as weekends that the flow would be as low as 45 cubic feet per second. Regulated flows have not yet been determined but the 7-day

regulated low flow having a recurrence interval of 10 years would be in excess of the seepage loss.

The feasibility of installing multiple-level power intakes to permit selection of the best quality water for release downstream should be investigated. Venting of turbines to increase the dissolved oxygen content is also a possibility to be considered.

It is assumed that sewage treatment plant effluent from the Jamestown area would continue to be discharged to Rockcastle Creek in the Obey River Basin west of Jamestown and that effluent from the Oneida area would continue to be discharged to Pine Creek from which it would enter Devils Jumps Reservoir.

Jamestown is located on the divide between the Obey River Basin and South Fork Cumberland River Basin, and Oneida is at the headwaters of Pine Creek. Drainage areas near these locations would not yield sufficient storage for flow augmentation purposes. Therefore, as the communities grow, it may be necessary to provide additional waste treatment beyond secondary in order to protect water quality in the Obey River Basin and in Devils Jumps Reservoir.



WATER SUPPLY AND WATER QUALITY CONTROL STUDY
DEVILS JUMPS RESERVOIR
CUMBERLAND RIVER BASIN
KENTUCKY-TENNESSEE

LOCATION MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
EVANSVILLE FIELD STATION, INDIANA — OHIO RIVER BASIN PROJECT

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

Parker Branch Reservoir

by

U.S. Department of the Interior
Federal Water Pollution Control Administration
Ohio Basin Region
Cincinnati, Ohio

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Ohio Basin Region
4676 Columbia Parkway
Cincinnati, Ohio 45226

IN REPLYING ADDRESS:

November 21, 1967

Colonel J. L. Fishback
District Engineer
Corps of Engineers
P. O. Box 1070
Nashville, Tennessee 37202

Dear Colonel Fishback:

Reference is made to a letter from your office dated March 21, 1967 requesting information on water supply and water quality control needs in the area that would be affected by the potential Parker Branch Reservoir Project, which is a part of the Appalachian Water Resources Survey.

We have evaluated the water supply and water quality control needs for the affected area to year 2020 based on developmental benchmarks and projections established by the Office of Business Economics and the Office of Appalachian Studies. Our findings are considered supplemental to the October 1964 "Water Supply and Water Quality Control Study; Rockcastle Narrows and Parker Branch Reservoirs, Cumberland River Basin, Kentucky," prepared by the U. S. Department of Health, Education and Welfare, Public Health Service, Region III, Charlottesville, Virginia. The report concluded that there were no benefits to be obtained from storage in Parker Branch and/or Rockcastle Narrows Reservoirs for the purposes of water supply and water quality control. These conclusions are still valid based upon the present evaluation criteria.

In the Raccoon and Little Raccoon Creek areas of Laurel County, mining operations have caused acid and sulfate problems. Although the extensive mining ceased sometime ago, the streamflow is still acid most of the time. Values of pH below 5 have been recorded and the sulfate concentration exceeded 650 ppm at one time. Acid streamflow would have an adverse effect on water quality, and the Raccoon and Little Raccoon Creek areas of the reservoir would be of questionable value for recreational purposes.

Downstream of the confluence of Little Raccoon Creek and Rockcastle River, the water quality would be somewhat improved because of the addition of streamflow from areas generally free of significant acid streamflow.

The bacteriological quality of water stored in the reservoir should be satisfactory.

Sincerely yours,

R. A. Vanderhoof
Regional Director

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

Kingdom Come Reservoir

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Ohio Basin Region
Cincinnati, Ohio

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Ohio Basin Region
4676 Columbia Parkway
Cincinnati, Ohio 45226

IN REPLYING ADDRESS:

November 21, 1967

Colonel R. R. Wessels
District Engineer
Corps of Engineers
P. O. Box 59
Louisville, Kentucky 40201

Attention: William Leegan

Dear Colonel Wessels:

Reference is made to a phone call from your office on June 28, 1967 requesting information on water supply and water quality control needs in the area that would be affected by the potential Kingdom Come Reservoir Project, which is a part of the Appalachian Water Resources Survey. The project would be located at mile 130.2 on the North Fork of the Kentucky River in Letcher County, Kentucky.

We have evaluated the water supply and water quality control needs for the affected area to year 2020 based on developmental benchmarks and projections established by the Office of Appalachian Studies and the Office of Business Economics. Our findings are considered supplemental to the October 1964 "Water Supply and Water Quality Control Study; Carr Fork and Line Fork Reservoirs, Kentucky River Basin, Kentucky," prepared by the U. S. Department of Health, Education, and Welfare; Public Health Service, Region III; Charlottesville, Virginia. The report noted that water supply needs to year 2020 could be met from present sources but that water quality control would be needed in the North Fork of the Kentucky River at Hazard after adequate waste treatment. Accordingly, it was recommended that the following streamflows be maintained in year 2020 at Hazard for the purpose of water quality control:

Month	Streamflow, cfs
Jan., Feb., Mar.	8
Apr., May, June	25
July, Aug., Sep.	28
Oct., Nov., Dec.	19

For year 2020 it was estimated that a draft-on-storage of 2,300 acre-feet would be required to meet the above flows during a once in 20-year drought

Using current criteria which reflect the developmental effects of the Appalachian program, we find that for water quality control, the following streamflows should be maintained at Hazard for 2020 conditions of development:

Month	*Streamflow, cfs
Jan., Feb., Mar.	11
Apr., May, June	36
July, Aug., Sep.	40
Oct., Nov., Dec.	27

*Includes streamflow to be supplied from Carr Fork Reservoir

It is estimated that a draft-on-storage of 3,400 acre-feet would be needed to meet the above flows during a once in 10-year drought which is the criterion now being used to determine supplemental storage for the purpose of water quality control.

In the absence of the Federal project, the water quality control objective could be achieved by constructing a reservoir for the purpose of augmenting natural streamflow. When allowances are made for sediment and evaporation losses, a total storage of 4,200 acre-feet is needed to meet the objective. The total investment cost for this quantity of storage would be $1,520,000. When this investment is amortized over a 100-year period at an interest rate of 3¼ percent, and an allowance is made for operation and maintenance costs, the total annual cost is $82,000. This is the annual benefit for water quality control flows to be supplied from Carr Fork and/or Kingdom Come Reservoir.

We find no apparent need for municipal and industrial water supply to year 2020. The dependable North Fork flow and capacity of existing storage facilities are adequate for these uses.

In the headwaters of the North Fork above Whitesburg and in the Rockhouse Creek area, iron concentrations in excess of 1.0 ppm occur a large percentage of the time, and streamflow is often acidic as a result of coal mining operations. These factors can cause a loss in reservoir recreation potential. The presence of iron floc on the streambed and acidic conditions would hinder development of a sport fish population. The situation would probably be most critical during periods of rainfall when iron floc previously deposited on the streambeds of minor tributaries during relatively dry periods would be carried downstream into the reservoir. To minimize these effects, an effective acid mine pollution abatement program would have to be established. The bacteriological quality of water stored in the reservoir would be satisfactory for most purposes provided that wastes from the community of Whitesburg are adequately treated.

Sincerely yours,

R. A. Vanderhoof
Regional Director

PART VI - GREAT LAKES REGION

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

Conneaut Creek Project

by
U. S. Department of the Interior
Federal Water Pollution Control Administration
Great Lakes Region
Chicago, Illinois

C O P Y

December 8, 1966

Colonel Wilson Neff
District Engineer
Buffalo District
Corps of Engineers
Foot of Bridge Street
Buffalo, N. Y. 14207

Dear Colonel Neff:

We have reviewed the Draft Survey Report for Flood Control on Conneaut Creek at and in the vicinity of Conneautville, Pennsylvania as you requested.

Our only question would be in relation to paragraph 17, on page 6. We feel that consideration should be given to installing a sewerage collection system and secondary treatment plant for Conneautville at the time of or before the channel improvements are constructed. As agreed to by the various states involved and the Federal Government at the Lake Erie Enforcement Conference, all municipal wastes are to be given secondary treatment, and no new combined storm and sanitary sewers are to be built. Therefore, no structures such as those proposed should be constructed which are a part of a system which continuously discharges untreated sewage.

Sincerely yours,

H.W. Poston
Regional Director
Federal Water Pollution
Control Administration

GPratt:arw

C O P Y

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

Stannard Reservoir (Genesee River)

by
U. S. Department of the Interior
Federal Water Pollution Control Administration
Great Lakes Region
Chicago, Illinois

C O P Y

August 29, 1967

Mr. Ralph H. Gallinger
Chief, Engineering Division
Corps of Engineers
Foot of Bridge Street
Buffalo, New York 14207

Dear Mr. Gallinger:

We have completed our review of the Genesee River and its tributaries in Allegany County as requested in your letter dated August 8, 1967. It appears that, even with the assumption that the growth rate of the area can be accelerated, the main stem of the Genesee River will be adequate for water quality control provided good secondary treatment (better than 90 percent) is installed. Three communities on tributary streams of the Genesee River must provide advanced waste treatment to maintain the water quality standards of the receiving water unless upstream storage for water quality control is determined feasible and made available.

The only sector on the main stem of the Genesee River that is projected to receive a significant waste discharge and for which a reservoir at Stannard needed examination for agumenting the streamflows for dilution is the reach below Wellsville. This village was projected growing from its present population of 5,967 to over 17,000 in the year 2020 based on developmental benchmarks. However, with conventional secondary treatment providing a high degree of organic removal, the capacity of the stream is estimated to be about 130 percent greater than anticipated loading in the year 2020.

The water quality in the other sectors, Dyke Creek below Andover, Van Campen Creek below Friendship, and Angelica Creek below Angelica, is estimated being contravened in the years 2000, 2010, and 1980, respectively, if the projected loadings materialize. Advanced treatment, or treatment that provides organic removals in excess of 90 percent, will be sufficient to maintain adequate quality water in these three receiving streams, but consideration should also be given to determining the feasibility of providing upstream storage in each of these creeks for water quality control. We will be glad to furnish the streamflow requirements on these three stream sectors if your office determines reservoir sites are feasible on any one or all of them.

C O P Y

We do not have sufficient information to evaluate the streamflow requirements for diluting the wastes from the proposed pulp mill and petrochemical plant near Wellsville. It does appear that a minimum daily flow of 140 cfs would be adequate for a pulp mill with a waste discharge of 20 mgd, assuming good secondary treatment.

If you have any questions or need additional information please feel free to contact Mr. Lee Townsend at our Lake Ontario Program Office.

Sincerely yours,

H. W. Poston
Regional Director

[Note: The basis for these conclusions may be found in the report entitled "A Water Pollution Control Program for the Genesee River Basin," prepared jointly by United States Department of the Interior; Federal Water Pollution Control Administration; Great Lakes Region; Rochester Program Office; Rochester, New York; and New York State Department of Health; Environmental Health Services, Division of Pure Waters; Albany, New York.

Additional information is also contained in Appendix H of the "Genesee River Basin Comprehensive Study of Waters and Related Land Resources," prepared by the New York State Health Department.]

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C O P Y

October 27, 1967

Mr. Ralph Gallinger
Chief, Engineering Division
U. S. Army Corps of Engineers
Foot of Bridge Street
Buffalo, New York 14207

Dear Mr. Gallinger:

We have made a preliminary estimate of the water quality requirements for the Genesee River below the proposed pulp and paper mill below Wellsville. We have found that the 50 MGD figure quoted in the proposal for dilution of the mill's waste to be adequate if the stream's assimilative characteristics are indeed moderately favorable, as they appear to be. Before any definitive statement of the river's assimilative capacity can be made, however, some detailed field surveys would be required. We do not anticipate having the resources to do this at the present time, but at some future date this could probably be arranged if validation of our estimates became necessary.

The location of the proposed mill is between Wellsville and Belmont. We have determined that the preferred location, from the water quality standpoint, is about five miles downstream near Scio. This would provide adequate recovery time for the Village of Wellsville's waste.

With regard to the effect of the nutrient loading emanating from the proposed pulp and paper mill waste, it is assumed some form of chemical coagulation or other treatment would be included for removal of phosphorus and/or other nutrients in the design of the mill's waste treatment plant.

Based on our preliminary estimates, the Stannard site would be required to supply up to 50 MGD (80 cfs) during the periods of low flow. Comparison of this flow requirement with the mean monthly flows that occurred during the 1963-64 critical water year yielded a net storage requirement of 5,100 acre feet. Only August and September had mean monthly flows less than 80 cfs during this period.

We appreciated the opportunity to comment on this proposal and hope our information will aid in your evaluation.

Sincerely yours,

H. W. Poston
Regional Director

C O P Y

APPALACHIA PROGRAM

WATER SUPPLY AND WATER QUALITY CONTROL NEEDS

Zoar Reservoir (Cattaraugus Creek)

by

U. S. Department of the Interior
Federal Water Pollution Control Administration
Great Lakes Region
Chicago, Illinois

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UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION
33 EAST CONGRESS PARKWAY, ROOM 410
CHICAGO, ILLINOIS 60605

June 13, 1968

Col A. L. Wright
Buffalo District, Corps of Engineers
Foot of Bridge Street
Buffalo, New York 14207

Dear Colonel Wright:

Reference is made to Col. Neff's letter of April 10, 1967 to George Harlow and our reply of June 9, 1967 regarding storage requirements of the Zoar Reservoir on Cattaraugus Creek.

In our reply we stated that ".....The recommended level of treatment for Gowanda will be 90 percent BOD removal." That recommendation should be revised in accordance with the Lake Erie Enforcement Conference recommendations, the water quality standards program, and our own comprehensive water pollution control program recommendations.

Thus our recommendation now is that the Peter Cooper Corp. and Maench Tanning Co. connect to the Gowanda Sewage Treatment Plant, and that the plant provide advanced waste treatment (98 percent BOD_5 removal) and maximum phosphorus control consistent with available technology.

It should be noted that Nuclear Sewer Service Inc., West Valley, N.Y., discharges its waste (including radioactive waste) to a small tributary which enters Cattaraugus Creek upstream of the proposed reservoir.

Sincerely yours,

H. W. Poston
Regional Director

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